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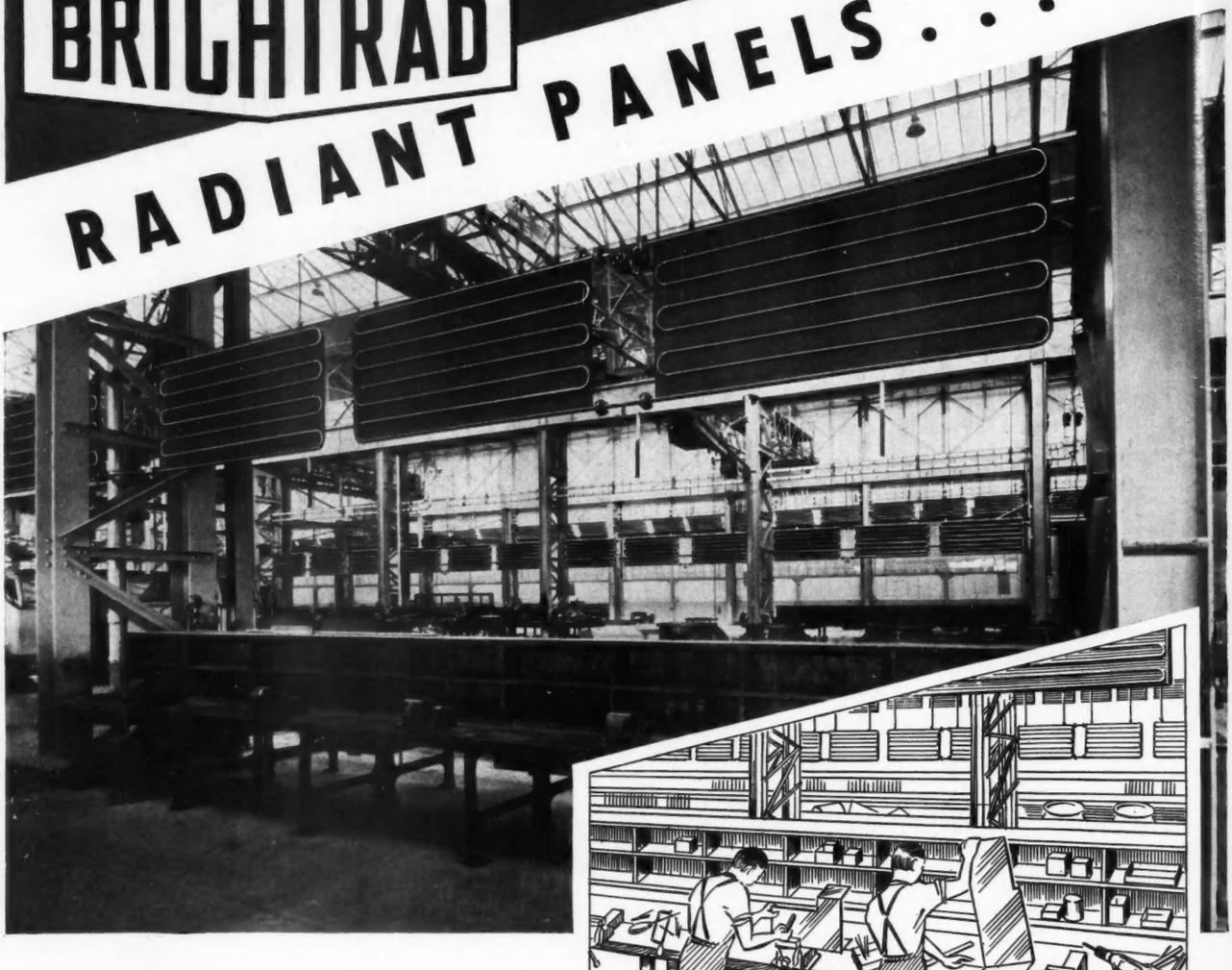

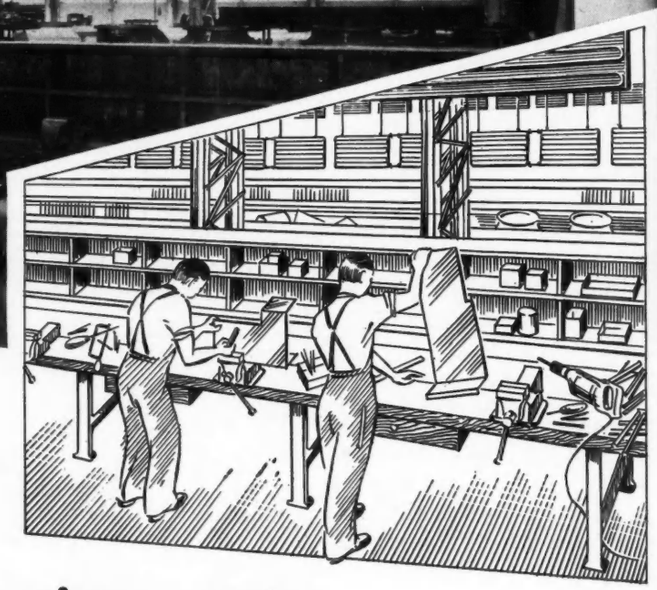

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PLANNED CITY

BY 1951 India had emerged from the troublous years which began her life as an independent nation and was ready to undertake the construction and development which would increase her stature and lead her people to a richer way of living. Thus, in that year was inaugurated the first Five Year Plan, of which the building of Chandigarh was to form a small part. This city, built under the guidance of the great French architect Le Corbusier on the basis of a plan prepared by Mr. Albert Mayer of New York, is to be the capital of East Punjab. It is entirely modern in conception and is now largely complete.

The character of Chandigarh, its origins, and the place it occupies in the Five Year Plan were outlined in the Sir George Birdwood Memorial Lecture, delivered on February 3 before the Commonwealth Section of the Royal Society of Arts by Mr. E. Maxwell Fry and his wife Miss Jane B. Drew, who themselves played a very considerable part in the planning and development of the new capital. Mr. Fry dealt with the project as a whole, describing many of its features and the sometimes revolutionary ideas contributed by Le Corbusier. Miss Drew, in the second half of the lecture, covered the subject of housing, noting certain of the problems encountered and showing how they had been solved.

In discussing the Five Year Plan, Mr. Fry said that it could be defined as "an assessment of needs to be met by action," and its most important object was to increase the productivity of agriculture, in which 80 per cent. of the country's population was engaged. The great Sindri fertiliser plant and numerous irrigation and power-raising works were directed towards this end. By 1952-53 irrigation and power projects had provided a further 1½ million acres of fertile land and added 425 MW of generating capacity; in particular, the Bakhra-Nangal scheme in the north-east, the largest canal network in the world, would irrigate six million sun-scorched acres stretching through the Punjab and Pepsu to Rajasthan and the fringes of the Indian desert. It was into this framework that Chandigarh would fit.

In 1952 a team of architects, including Mr. Fry, Miss Drew and M. Pierre Jeanneret, a one-time partner of Le Corbusier, met to formulate with Mr. Mayer a final plan and to take part in the vast adventure of city building. The key to modern city planning is separation of function. Pedestrians, for example, interfere with the progress of fast traffic, and motor vehicles may cause injuries to pedestrians if both use the same thoroughfares. Wherever possible, the principle of separation has been adopted in Chandigarh. The city lies on the main Delhi-Simla road. It is based on a rigid rectangular grid of fast-traffic roads, which intersect at half-mile intervals in one direction and three-quarter-mile intervals in the other. On these there are no footpaths and no frontal development sites. The rectangular living spaces between roads, which are approximately 240 acres in area and accommodate up to 15,000 people, are planned internally to serve as independent communities, each with a wide meandering green belt, schools, playing fields and most normal amenities.

Across these "sectors" runs Bazaar-street, on the shaded side of which are situated shops, offices, cinemas and the usual facilities of any main street. It is indirect, and staggered at its junctions with the fast-moving grid to discourage speeding along its length.

Housing, which is located in four quarterings of each sector, is of considerable architectural diversity and designed on a basis of income groups. It is universally modern in form with emphasis on coolness and convenience, and generally conceived to satisfy local traditions and habits. Public buildings, too, are of interesting and elegant construction. Set in spacious surroundings modified by landscape gardening, they serve perhaps as the focal points of the city. In particular, the Capitol, comprising a fascinating assymetrical group of government buildings, has received special attention from Le Corbusier. The High Court is a typical product of his imagination: it is a large and finely proportioned building over which is carried, on a single support stretching the length of the building, a pair of immense cantilever wings; these serve in effect as a great "parasol" to protect the main block from the fierce rays of the sun. And adding to the grace of the buildings is the majestic backcloth of the Himalayan foothills.

Although the whole scheme is conceived on a grand scale, it has been governed by an estimate calculated on a basis of 150,000 people and 8,919 acres of land, with a possible extension to half a million people later. A total cost of nearly £13 million was envisaged for the first phase, but sums recovered by sale of plots to the public and from other sources made possible a considerable reduction in actual expenditure. Much of the building is now finished and many houses occupied.

To us in Britain a new town is not unfamiliar—several have been built since the war—but the building of a new capital city, such as India's Chandigarh, is a fascinating project. Surrounded, as we are in Bedford-street, by the vastness of Greater London—conscious, too, of its great history—we yet envy countries like India which can start at the very foundations, design and build a city, using ideas and techniques which we in the West discovered. Good luck to them!

Weekly Survey

Cover Picture. *The production of molybdenum rod by powder metallurgy involves the making of a "compact" by subjecting molybdenum powder contained in a mould to hydraulic pressure. The pressed-powder rods produced are fragile and, to enable them to be handled, they are brought to a temperature of incipient fusion by a pre-sintering treatment. In the final sintering operation shown on our cover, the rods are clamped at the top in water-cooled electrodes, while their lower ends are held in clips partly immersed in pots of mercury. During the sintering operation, which is carried out by passing a heavy current through the rods, the cylindrical copper water jackets, seen in the illustration, are lowered over the rods to stop the intense radiation of heat and also to contain the hydrogen necessary to prevent the oxidation of the incandescent molybdenum.*

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CLEARING THE AIR

Mr. Duncan Sandys, Minister of Housing and Local Government, promised in the House of Commons on February 4 that the Government will introduce this session a comprehensive measure, based on the Beaver report, for the abatement of atmospheric pollution and smoke. After this promise Mr. Gerald Nabarro, Member for Kidderminster, withdrew his private member's Clean Air Bill, which had been debated for nearly five hours. The Government will be able to introduce financial clauses into their Bill, and will benefit from consultations they are having with local authorities, industry, and certain technical bodies. The principles of Mr. Nabarro's Bill were strongly supported on both sides of the House, and there can be little doubt that the recommendations of the Beaver report will be largely incorporated in a Government Bill before the end of this year.

If the Government's Bill follows the lines of Mr. Nabarro's, the effects on industry will be considerable. After a certain date, appointed for a district by the local authority, the amount of grit emitted by a chimney will be limited, and dark smoke will be prohibited. This provision will at first apply only to new installations, but after a certain period—in Mr. Nabarro's Bill three years—the provision will be extended to all industrial premises with certain special exceptions.

There are already incentives for greater fuel efficiency; money for fuel-saving equipment can be obtained as a loan from the Government, and the period for the repayment of this loan has been extended so that it is the same period as that allowed by the Inland Revenue for wear and tear purposes upon the plant installed. The industrialist has to find no money to meet the capital cost of the equipment, and year by year has to find no money out of net resources for the repayment of the loan. Those who have installed fuel-saving equipment which has reduced smoke and grit emission will find themselves well placed when the Government's Bill is passed.

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DEVELOPMENT IN THE COLONIES

The Colonies continue to be both actually and potentially an important outlet for British engineering equipment and consulting services. Their record in recent years has been much more consistent in this respect than that of the Dominions. While it is always possible that a sudden reversal of fortune may occur in world commodity markets, and so quickly and seriously affect the prosperity of such overseas territories, the indications at the moment are that no major change is likely in the foreseeable future in the general level of prosperity in the Colonies.

The continued intention of the Government to supply a limited though assured sum for economic and social development in the Colonies was evinced last week with the publication of the White Paper on Colonial development and welfare. Legislation is to be introduced to provide £80 million of new money for the Colonies over a five-year period. There is still also £40 million unspent under the Colonial Development and Welfare Act which expires on March 31 this year.

There are two additional points to be noted. Firstly, the White Paper considers that the Colonies overall will require more finance from outside in loans and grants than they have had in the last five years. Secondly, the amount of money to be allocated varies greatly between Colonies. In West Africa, for instance, the Gold Coast is expected to provide most of its finance for development from internal resources, but in the case of Nigeria which is only a few hundred miles away, almost half has to come out of the Colonial Development and Welfare Fund. Another contrast is in East Africa, where most of the capital for Northern Rhodesia's programme for development will come from local sources. It would thus appear that those areas which are particularly prosperous at present will sustain continued ambitious development programmes over the next few years and in those areas where there may be some difficulty in raising the necessary funds internally, the Colonial Development and Welfare Fund will be mobilised to give the maximum assistance.

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RAILWAYS IN ASIA

Technical problems relating to the efficient working of railways—the use of concrete, wooden and metal sleepers, the prevention of corrosion, the treatment of locomotive boiler water, and many others—were discussed at the Fourth Session of the Inland Transport Committee of the United Nations Economic Commission for Asia and the Far East (ECAFE), which met at Bangkok last month. The delegates of the 15 countries represented also discussed the increasing use in Asian countries of Diesel locomotives, and the secretariat of ECAFE were instructed to prepare a report "to facilitate decisions of national railway administrations about the purchase of locomotives best suited to local requirements." The earlier reports prepared by the secretariat on railcars, containing detailed information on technical trends of railcar construction and on the use of railcars in Western as well as Eastern countries, have proved most useful documents for railcar manufacturers as well as for users and potential users. A similar report on the use of Diesel locomotives, including analyses of operating costs in various parts of the world and a discussion of the various types available, will doubtless be welcomed as much by the Western builders, particularly the British industry, as by the Asian countries.

Delegates at Bangkok stressed the interest of the railway administrations of their countries in the exchange of technical information, and in the supply of trained technicians. They heard reports on the progress of the United National Regional Railway Training Centre in Lahore, where courses for railway operating officials are being held. As a result of an earierl suggestion by ECAFE, an Asian training centre for Diesel marine mechanics will begin operating in Rangoon early this year. There is an urgent need for technicians to provide a satisfactory maintenance service for the many Diesel engines that have replaced steam in local shipping. Similarly, little success can be expected from the introduction of Diesel locomotives and railcars unless men can be trained to look after them.

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ROAD PROSPECTS

Last Wednesday, February 2, in the House of Commons, the Minister of Transport announced the details of the first instalment of the plans for an expanded road-construction programme. He referred to a number of projects to be tackled within the next four years at a cost of £147 million, and intimated that towards the end of that period a start would be made on two major motorways —London to York (with a branch to Birmingham) and Birmingham to Preston—at a cost of £65 million. It was possible, though no final decision had yet been taken, that tolls would be levied to help the Treasury meet the cost of these motorways. Specific plans laid before the House included bridge building, elimination of "black spots," widening of trunk roads and the construction of scores of by-passes. This was, said the Minister, the commencement of a substantial programme of road construction and improvement that would continue until the roads of the country were adequate for the traffic they had to bear. A list of the proposed works referred to in the Minister's statement is given elsewhere in this issue.

Thus within ten days details were published of proposals to improve the communications of the United Kingdom in respect of both the roads and railways. In comparing the two plans—and bearing in mind that industry generally prefers road transport wherever possible —it should be remembered that the £147 million for roads is the Government's intended expenditure in the next four years on the carriageways themselves (that is to say, no part of that sum is intended for vehicles) whereas the £1,200 million plan for the railways, spread over 15 years, is only what the Transport Commission would like to do if they can raise the necessary money and that about two-thirds of the sum is in respect of motive power and rolling stock.

In regard to the road programme there is little doubt that the manpower and materials are available and that the civil-engineering industry can absorb the work without difficulty. Moreover, earlier legislation has ensured that all the powers are available to enforce the acquisition of the necessary lands, but whether, when it comes to particular points, public opinion will allow the law to be enforced has yet to be seen. During the past week there has been renewed campaigning for a National Highways Board which would, in respect of roads, take responsibility for many matters which are at present distributed over several authorities including various Government departments, as well as county and municipal councils.

Perhaps the most disappointing aspect of the road plan as announced is the omission, or elimination by substitution of alternatives, of certain attractive major bridge projects, in particular those for the Severn and the Forth. In the case of the latter, mention has been made of laying a tube across the bed of the river, an expedient which, if practicable, would be cheaper than either a bridge or a tunnel, and, if successful, might materially raise the possibility of the Channel tube being undertaken.

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SCOTS WITHOUT AMBITION?

It is a serious sign of the times when a report from Scotland states that "The old Scottish thirst for self-education, self-improvement and self-advancement seems to have become not only unfashionable but almost lacking in social virtue." These words have come from the Glasgow Productivity Committee, who have been studying technical education in the city for the past year and a half. They come to the conclusion that insufficient use is made of the technical facilities available in Glasgow both by employers and employees. It was found that of the hundreds in Glasgow who enroll in trade courses annually, 10 per cent. never attend a class. 30 per cent. give up after the first few months and only 25 per cent. enroll the second time. Of this 25 per cent., only 5 per cent. receive a certificate of qualification at the end of three years. This disturbing rate of wastage was found to be less in day than in evening classes.

A report of this kind from any large industrial centre would be a cause for anxiety. It is particularly so coming from Glasgow. The city is admirably equipped with a technical education

system which pyramids down from the University and the Glasgow Technical College. This educational system, only the technical side of which concerns us here, has for generations provided the springboard from which the sons of the citizens of Glasgow have launched themselves into professional careers at home and abroad. It has, as well, attracted more than its share of the ambitious able youngsters from the Highlands and the South West. If Glasgow is to flourish, and the rest of Scotland and the United Kingdom as well, steps will have to be taken to ensure that an adequate flow of young people is maintained through the various grades of technical education in those centres which are by tradition and inclination admirably equipped to cope with them.

* * *

THE BURNTISLAND GROUP

Attention was drawn in the Weekly Survey for January 7 to the high level of activity in the Scottish shipbuilding industry last year. Among the beneficiaries from this prosperity was the Burntisland group, comprising the Burntisland Shipbuilding Company, Limited, Hall Russell and Company, Limited, and Alexander Hall and Company, Limited. The group has a potential output of 120,000 gross tons per annum and two works in Aberdeen for the construction of modern steam machinery.

Notable achievements of the group include the Burntisland "economy" ship in 1930 and, during the last war, the prototype merchant aircraft carrier with provision for the loading of grain through hatches trunked through the flight deck. In recent years the output of the Burntisland Company has included cargo liners up to 10,000 tons, which have largely superseded the old-fashioned tramp vessels, specialised bulk carriers for the ore trade and modernised coastwise and up-river colliers. Hall Russell are particularly associated with the building of trawlers. Their output has also included whale catchers and short sea traders of liner type. Ships built by Alexander Hall have included fishing vessels, high-powered tugs, salvage vessels, Admiralty craft and dredgers. The varied nature of the group's output has put them in a strong position to meet the overseas demand for vessels of specialised design, which has been a marked feature of export demand in the post-war years.

Writing in the Burntisland group journal, the chairman, Sir Wilfrid Ayre, recently had something to say regarding complaints of the high price level of new ships. Apart from the factors making for high prices throughout the national economy, technical complication in ship design and equipment has been very considerable. Among other factors cited are the greatly increased use of electricity in the ordinary cargo ship, the improvement in the standard of crew's quarters, the increase in speed required and the increasing specialisation in design.

The fact that the majority of these improvements cannot under present conditions be dispensed with and that therefore the price of new ships must inevitably remain high, makes it all the more necessary for shipbuilders and industries supplying their raw materials and equipment to reduce costs if British shipbuilding is to maintain its present strong position against foreign competition.

* * *

PLANT FOR THE FUEL AND POWER INDUSTRIES

The past year was a good one for manufacturers of plant for the fuel and power industries. But as the article in the Engineering Outlook series on page 170 shows, prosperity was confined very largely to the home market. Exports of mining machinery in particular were severely down and the export performance of manufacturers of heavy electrical plant, due mainly to disappointing demand in the Dominions, was only indifferent. Although the lull in demand overseas is likely to persist, there can be no slack in British manufacturers' order books for the next five years at least. The expansion programmes of the electricity, gas and coal industries require an investment of £2,256 million between now and 1960. In the coal industry, where the investment programme had fallen considerably into arrears, some progress began to be made against the leeway in 1954, when the outlay reached £83 million compared with £64 million in 1953 and £49 million in 1952. In the electricity generating industry, 1,400 MW of new capacity was installed in 1954, and the industry plans to increase this gradually to 2,000 MW in 1959.

Looking beyond 1960, the outlook is greatly changed by revolutionary developments taking place both in the fuel and power industries and in consuming industries. Whereas it had been anticipated that, despite all the progress which could be made by mechanisation in the mines, there would be a gap between the supply and potential demand for coal of 20 million tons by 1960, the task of bridging this gap now seems much less hopeless. At present the railways are using about 13 million tons of coal per annum, and the change to Diesel and electric power, under the new 15-year programme, although far from complete, should have achieved substantial economies by 1960. The British Electricity Authority is also to some extent turning to oil. Bankside is the only power station at present operating on oil, but Marchwood power station, due for completion in 1956, will have equipment for both coal and oil firing. Something will also be gained from the work of the National Industrial Fuel Efficiency Service, who have set themselves the ultimate target of saving 9 million tons of coal a year, and from the Clean Air Bill when it becomes law. The large-scale use of nuclear power may not be so far off as is commonly supposed.

The future for manufacturers of plant for the fuel and power industries may thus greatly change after 1960, when other forms of energy become more and more competitive with dear coal.

* * *

FUELS FOR POWER STATIONS

Some interesting estimates regarding the trend of fuel consumption for electricity generation in European countries over the next four years are given by the Organisation for European Economic Co-operation in their third inquiry entitled "Fuel Consumption of Thermal Power Stations."

The figures show a decline in the proportion of the total output of electricity to be derived from high-grade coal, which is defined as coal with a calorific value exceeding 4,500 k.cals. (equivalent to about 8,100 B.Th.U. per lb.) and a smaller decline in the percentage derived from fuel oil. On the other hand the proportion derived from low-grade coal and from lignite is rising. Over the period from 1952 to 1958 the total output of electricity from public-utility thermal stations in all the O.E.E.C. countries is expected to increase by 58 per cent. from 109,773 million kWh to 173,762 million kWh. In 1952, 81 per cent. of the total was generated from high-grade coal but by 1958 this will have fallen to 76·8 per cent., while the proportion generated from low-grade coal will have increased from 2·1 per cent. to 2·8 per cent., and that from lignite from 9·3 per cent. to 12·9 per cent.

In this country, of course, substantially the whole of the output is derived from high-grade coal and little change is likely until atomic energy begins to contribute on a substantial scale, though it is expected that the output from low-grade coal will increase from 100 million in 1952 to 500 million kWh in 1958. Other countries which will make substantially increased use of low-grade coal are Belgium (2,400 million kWh in 1958 compared with 1,495 million kWh in 1952), Denmark (1,190 million kWh compared with 545 million kWh) and Turkey (600 million kWh in 1958 against nil in 1952). The biggest increase in the use of lignite will occur in Germany, where already in 1952 8,933 million kWh or 27 per cent. of the total output was derived from this source. By 1958 these figures will have increased to 18,500 million kWh and 45 per cent. Other countries which plan to increase substantially their output of electricity from lignite include Austria, France and Turkey.

* * *

STEEL SHEET COMPLICATIONS

When the programme for steel output in the next few years was announced last month the industry declared that it planned to cater for an overall demand of about 21 million tons of ingot steel by 1957-1958. These plans included building half a million tons of new sheet capacity and half a million tons of new tinplate capacity. It was not thought at the time that this increase in strip capacity was likely to do more than meet the minimum increase in demand for sheet and tinplate for the next few years, but the British Iron and Steel Federation reckoned that any sharp change in demand could be met by an increase in imports.

But the United States steel industry, which might satisfy sudden increases in the U.K. demand for sheet and tinplate, may not be able to help in this way. It is reported that sheet-steel mills have full order books through the first quarter of the year and that some have taken orders as far ahead as June. The prospects for the U.S. sheet-steel industry are very heavily dependent on the American automobile industry, which has come through the recent recession with remarkable stability. If demand for cars does not weaken (and it would be unusual for the U.S automobile industry to fail to participate in a growth of prosperity in America) the exportable surplus of sheet-steel in the second half of this year may be very small and certainly inelastic. The British expansion programme for strip announced five weeks ago may, indeed, prove to have been on the conservative side.

* * *

THE ENGINEER AS BUSINESS MAN

In his paper to the British Association last autumn (ENGINEERING, vol. 178, page 329), Mr. Bosworth Monck drew attention to the decline of the professional engineer in the direction of British companies and suggested that this was a dangerous trend. In the latest number of the journal of the Research Centre in Entrepreneurial History at Harvard, there is an interesting article by Mr. John B. Rae, of the Massachusetts Institute of Technology, entitled "The Engineer as Business Man in American Industry."

This is a preliminary study and its conclusions are only tentative, but it has led its author to certain hypotheses which appear to apply to all industries. Engineers have never constituted a majority of the business leaders in any industry, but their influence is not a function of their numbers. It is during the pioneering stages of an industry that engineers have been most conspicuous as leaders, in situations where the basic problem was to make a new technical development commercially possible. Engineers again become prominent in management after an industry has reached a condition of relative stability, frequently after an era of price wars, pooling agreements and consolidation. Obviously, industries subject to constant technical innovation have a strong engineering representation in management; but which is cause and which is effect is not clear. Engineers have been more successful in becoming heads of small businesses than of large. Questions of social prestige have played their part in the role played by engineers in different industries, for instance, the fact that the New England merchant-capitalists of the early Nineteenth Century tended to classify all technicians as "mechanics" led to a subordination of engineers in the textile industry, in contrast to the automobile industry which developed in a very different social climate.

PROPOSED ROAD CONSTRUCTION

Government's Four-Year Plan

The following are among the schemes referred to by Mr. Boyd-Carpenter, Minister of Transport and Civil Aviation, in a statement in the House of Commons on Wednesday, February 2, on the first stage of the Government's plans for modernising the country's roads (including certain schemes previously announced):—

A. SCHEMES IN ENGLAND AND WALES PROPOSED TO BE AUTHORISED IN 1955-56 ON TRUNK ROADS (EACH COSTING OVER £100,000) AND ON CLASSIFIED ROADS (EACH COSTING THE EXCHEQUER OVER £500,000).—Alconbury Hill to Woolpack Cross Roads (second carriageway), A.1; Allerton Station (Hopperton) by-pass, A.1; Browney Bridge to Farewell Hall, widening, A.1; Borrowash by-pass, A.52; Catterick by-pass, A.1; *Dartford-Purfleet Tunnel; East Retford by-pass (Elkersley by-pass to Five Lane Ends), A.57; *Elephant and Castle improvement (Part 1), A.3; Handcross by-pass, A.23; Lichfield-Burton road (part), second carriageway, A.38; Longton by-pass, A.59; Neath by-pass (Part II), A.48; Newcastle boundary to Chapel House, Throckley (widening), A.69; Oxford boundary to Islip Turn (widening), A.40; Page Street to Mill Hill (second carriageway), A.41/A1; Potter Street diversion, Harlow, A.11; Ryton-on-Dunsmore to Coventry (second carriageway), A.45; Shenstone, widening carriageway for one mile east of A.38, A.5; Stamford boundary to Kesteven boundary (widening), A.1; Stratford Road, Shirley (widening), A.34; Tabernacle Chapel to Llanfair Discoed Arches, A.48; Western Avenue, second carriageway between Park Royal Station and Greenford Halt (Part II), A.40; Woodbridge by-pass, widening carriageway, A.12.

* Classified road schemes: pending further consultations with the local highway authorities responsible for initiating schemes on classified roads, it has been considered desirable to exclude schemes below £500,000 (Exchequer cost). It is, however, expected that Exchequer expenditure will be divided about equally between classified road schemes and trunk road schemes below £500,000.

B. SCHEMES IN SCOTLAND PROPOSED TO BE AUTHORISED IN 1955-56 (EACH COSTING THE EXCHEQUER OVER £100,000).—TRUNK—Bridge of Allan, A.9; Dumbuck to south-east of Barloan Crescent, A.82; Linlithgow Bridge, A.9. TRUNK AND CLASSIFIED—Bridge of Don, Aberdeen, A.92.

C. SCHEMES IN ENGLAND AND WALES PROPOSED TO BE AUTHORISED IN 1956-57, 1957-58, AND 1958-59 (EACH COSTING THE EXCHEQUER OVER £500,000).—(i) LONDON-YORKSHIRE MOTOR ROAD (PART). (ii) TRUNK ROADS.—Angel Road Bridge, Edmonton, A.406; Brynmawr-Abergavenny, A.465; Doncaster by-pass, A.1; Gateshead-Felling by-pass (part classified), A.184; Grantham by-pass, A.1; Harlow by-pass, A.11; Hirwaun-Brynmawr, A.465; Kingston by-pass, second carriageway between Robin Hood Gate and Burlington Road, A.3; Lancaster by-pass, A.6; Maidenhead by-pass, A.4; Maidstone by-pass, A.20; Northwich by-pass (completion), A.556; Oxford Ring Road (Botley to Wolvercot), A.34; Port Talbot by-pass, A.48; Preston by-pass, A.6; Ross Spur; St. Albans by-pass, A.5 and A.6; Sandiacre-Stapleford by-pass (Derby), A.52; Stafford-Stoke road widening, A.34; Staines by-pass, A.30; Tilbury Docks approach road, A.13; Western Avenue—Hangar Lane flyover, A.40. (iii) CLASSIFIED ROADS.—Albert Bridge reconstruction, B.304; Barton Bridge, Lancashire, A.575; Blackwall Tunnel, northern approach road, A.102; City of London redevelopment—various schemes; Elephant and Castle improvement part (II), A.3; Holborn-Kingsway junction improvement (part I), A.40 and A.4200; Huddersfield Central Ring Road (southern section); Laira Bridge, Plymouth, A.379; London Road-Chester Road, Manchester (East West link road), A.57; Manchester Outer Ring Road, A.575; Notting Hill Gate improvement, A.40; Strand widening, A.4; St. Giles Circus (Part I, S.E. corner), A.40.

D. SCHEMES IN SCOTLAND PROPOSED TO BE AUTHORISED IN 1956-57, 1957-58, AND 1958-59 (EACH COSTING THE EXCHEQUER OVER £500,000).—(i) TRUNK ROADS.—Abington and Crawford Diversions (including intervening lengths), A.74; Auldton Heights to 1·7 miles south of Millbank, A.74; Beattock to Johnstone Bridge, A.74; Dalmakether to north end of Lockerbie Diversion, A.74; Glasgow-Stirling road, A.80; Improvement from Malletsheugh to Eastwood Toll, A.77. (ii) CLASSIFIED ROADS.—Whiteinch Second Tunnel.

The proposed road programme is the subject of comment in Weekly Survey.

"VISCOUNT" PRODUCTION

Increased Capacity at Hurn Factory

In order to meet the increased demand for Vickers Viscount propeller-turbine airliners, Vickers-Armstrongs Limited have expanded the main Viscount production factory at Hurn, near Bournemouth. The alterations and additions, which were first planned in August, 1954, are now nearly complete and all the new production space will be in use by the end of February.

Originally there were two Viscount erecting shops, 342 ft. in length. Each was capable of holding only five fuselages—three with wings fitted, and two in the pre-wing stage. Both these shops have now been extended to a length of 796 ft. plus side annexes. They can now each accommodate 12 fuselages—six with complete wings and six fitted with inner planes. Thus, with both shops in use, erecting work can proceed concurrently on 24 fuselages. One of the enlarged shops, seen in the accompanying illustration, has been in operation for some time and by the end of February the extensions to the second will be available for use.

To keep pace with the demands of the new erecting shops, the fuselage shop has been doubled in size and the number of fuselage assembly jigs is being increased from three to eight. The number of fuselage sub-assembly jigs has also been more than doubled.

In addition to the above extensions, new premises, giving an extra 49,000 square feet of floor space, have been taken over at the former Royal Air Force Headquarters site just outside the airport. This space is being used for metal treatment and for fitting shops. A second flight shed has also been provided, and new drawing office accommodation is being built which will treble the space available for work on special customer requirements, etc.

The requisite steps to increase the supply of sub-contracted Viscount components, such as wings, tail units, ailerons and flaps, have already been taken. A second source of chassis supply has been arranged. The Vickers-Armstrongs' Weybridge factory will continue to supply, in increased quantity, the fuselage hoops, presswork and part of the chassis requirements.

The expansion at Hurn has led to the labour force there being nearly doubled. The main trades involved have been those of fitters, fitter-assemblers and fitter-erectors. Drawing office personnel, already trebled during 1954, will be at least quadrupled when the new extension is completed. Nearly all the vacancies which arose were filled by local recruitment.

PRODUCTION RATE

The Viscount production rate at Hurn has been steadily worked up, and 55 aircraft are scheduled for completion in 1955. This is over double the output of 1954. The first aircraft of the Viscount 800 series will be introduced to the line during 1955 and deliveries will start in 1956. In spite of the inevitable slowing-up which will come from the introduction of a new type of Viscount, the production for 1956 will be a 50 per cent. increase on that for this year. A considerable further expansion of production can take place in 1957, but the schedules for that year depend upon the state of the order book.

The present total of Viscounts ordered is 178 aircraft, including the twelve 802 series aeroplanes for British European Airways. At the moment 46 aircraft have been delivered for service to five airlines—B.E.A., Air France, Aer Lingus, Trans-Australia Airlines, and Trans-Canada Airlines. Airlines which will take delivery of Viscounts in 1955 include B.E.A., T.C.A., British West Indian Airways Limited, Capital Airlines, Iraqi Airways, Hunting-Clan Air Transport, Misrair S.A.E., Butler Air Transport, Central African Airways and Linea Aeropostal Venezolana (Venezuela). Other aircraft are due for delivery to the Canadian Department of Transport and to the India Air Force. The Central African Airways aircraft will be the first of the Viscount 700 D series to be delivered.

* * *

CENTENARY OF ALUMINIUM AS A COMMERCIAL METAL

From June 1 to 11, in the Royal Festival Hall, London, S.E.1, an exhibition is to be staged to celebrate the centenary of aluminium as a commercial metal, to show the progress made by the metal since 1855 and, in particular, to illustrate the research and development, sponsored by the aluminium industry and the Aluminium Development Association, completed during the past ten years.

The exhibition is primarily directed to all present and potential users of aluminium, particularly to engineers, designers and architects; representatives of Government, local authorities, and industry in this country; to Commonwealth and overseas guests and to teachers engaged in university and higher technological education.

The exhibition is being designed by Mr. Ronald Dickens, M.B.E., and is to be divided into five sections, covering, respectively, the historical, research and production aspects, the present-day use of aluminium and the future of the metal. Many diagrams, models, drawings and photographs will be on view as well as full-scale examples of road and rail vehicles, boats, chemical and electrical plant and other exhibits.

On several days technical discussions will be held during the afternoon, summarising progress and future possibilities in the use of

One of the two erecting shops which have been lengthened from 342 ft. to 796 ft. Each shop can now accommodate 12 fuselages—six with complete wings and six with inner wings.

aluminium in shipbuilding, road transport, the railways, structural engineering, building, packaging, electrical engineering and other fields. The participants in these discussions will consist of professional men and specialists in various industries who will be specially invited to visit the exhibition and contribute to the discussions.

Further particulars regarding the purpose and scope of the exhibition may be obtained from the Aluminium Development Association, 33 Grosvenor-street, London, W.1.

* * *

WATER SUPPLIES IN THE LONDON AREA

Some Metropolitan Water Board Statistics

During the twelve months ending March 31, 1954, the daily average natural flow of the River Thames was 935·9 million gallons as compared to 1,411·0 million gallons for the preceding year. These figures are given in the 51st annual report of the Metropolitan Water Board published recently. During the year under review, the percentage abstracted by the Board and by the suburban water companies together amounted to 25·00; this figure compares with one of only 16·68 per cent. for the previous year. On 50 days the actual flow of the Thames fell below 200 million gallons per day and on 132 days it fell below 500 million gallons; on the other hand, the actual flow exceeded 3,000 million gallons on five days. The natural flow of the river during the year (341,601·3 million gallons) represented a yield of 6·12 inches of rain from the 3,855 square miles of the watershed area, or 23 per cent. of the general rainfall of 26·32 inches; each square mile of the watershed area thus yielded as stream flow 3·367 million gallons per inch of rainfall. (The general rainfall for the year was 1·89 inches less than the average—28·21 inches for the standard period of 1881-1915—the deficit being due to a very dry winter, the summer being wetter than usual.)

Excluding subsidiary engines and equipment of small auxiliary works, the total number of engines used by the Board is 297 with a total of 65,525 h.p.; these two figures include 15 portable pumps of 2,104 h.p. The fuel consumed for pumping purposes during the year was 102,555 tons of coal, 22 tons of coke, 1,182,479 gallons of oil and nearly 60 million units of electricity, together representing a total standard coal equivalent of 142,606 tons.

* * *

INSTITUTE OF REFRIGERATION

Fifty-Fifth Anniversary Dinner

The fifty-fifth anniversary dinner of the Institute of Refrigeration was held at the Savoy Hotel, London, on February 2. The President, Sir Charles Darwin, K.B.E., M.C., F.R.S., was in the chair, and the toast of the Institute was proposed by Monsieur Rene Varin, C.B.E., the Cultural Counsellor at the French Embassy.

In his reply, Sir Charles Darwin said that the present 3-year study courses were too short; they were mostly 4½ years abroad and would probably have to be extended here. In view of this the industry would have to be prepared to offer higher starting salaries, as they would be getting better-trained men. In a later speech, Mr. H. A. Secretan, chairman of the Board of Governors, spoke about the work of the National College for Heating, Ventilating, Refrigeration and Fan Engineering. The first appointment to the research scholarship in refrigeration had been made, and it was hoped that scholarships in other subjects would be introduced. Plans for extensions to the College were nearing completion.

PERSONAL

H.R.H. THE DUKE OF EDINBURGH, K.G., K.T., P.C., G.B.E., F.R.S., has been elected an honorary member of the Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3, and an honorary member of the Institution of Electrical Engineers.

SIR EWART SMITH, M.A. (Cantab.), M.I.Mech.E., M.I.Chem.E., has been appointed a deputy chairman of Imperial Chemical Industries Ltd. The company has two other deputy chairmen, MR. A. J QUIG and MR. S. P. CHAMBERS, C.B., C.I.E.

MR. BRYAN DONKIN, B.A. (Cantab.), M.I.E.E., A.M.I.C.E., has been elected President of the Engineers' Guild, 78 Buckingham Gate, London, S.W.1, for 1954-55. MR. I. A. CURREY, A.M.I.Mech.E., Assoc.I.E.E., has been elected chairman of the General Council of the Guild for 1954-55.

MR. H. EVAN PRICE has been elected President of the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Coventry.

MR. A. V. CLEAVER, F.R.Ae.S., has been appointed chief engineer (rockets) of the newly-formed Rocket Division within the framework of the Engineering Division of the de Havilland Engine Co. Ltd., Stag lane, Edgware, Middlesex. MR. W. N. NEAT, B.A., A.F.R.Ae.S., is Mr. Cleaver's deputy.

MR. C. J. WILLIAMS, A.I.M., has been appointed to succeed MR. J. A. WELLINGS as manager, castings division, High Duty Alloys Ltd., Slough, Buckinghamshire.

MR. R. W. BURKITT has been appointed to the newly-created post of deputy Comptroller-General of the Export Credits Guarantee Department, 9 Clements-lane, London, E.C.4.

MR. H. F. SMALLWOOD is retiring from his position as chairman and managing director of W. H. Dorman & Co. Ltd., Stafford, on March 31, after 30 years of service, and is also relinquishing his seat on the board. He will, however, continue to act as technical consultant to the company for a further period of years. MR. G. C. SAUNDERS, director and secretary, is also retiring on the same date having completed 42 years of service with the company. MR. DARBY HADDON is to be chairman as from April 1. Another director, MR. J. W. WHIMPENNY is to become general manager on Mr. Smallwood's retirement, while MR. W. E. MITCHELL will retain his position as chief engineer. MR. G. S. TUCKER is succeeding Mr. Saunders as secretary.

Mr. D. E. H. PEIRSON, LL.M. (Lond.), has been appointed secretary of the United Kingdom Atomic Energy Authority.

COMMANDER D. A. HENDERSON, O.B.E., R.N., professional officer in the marine navigational aids division of the Ministry of Transport and Civil Aviation, Berkeley Square House, London, W.1, retired on January 26, and has been succeeded by CAPTAIN H. MENZIES, R.N., hitherto assistant hydrographer at the Admiralty.

MR. H. H. SMITH, assistant manager, special-vessels department, Babcock and Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.4, has been appointed sales manager, Edwin Danks & Co. (Oldbury) Ltd.

MR. A. J. R. VEALE, Assoc.M.C.T., has been appointed superintendent, process and rate department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, in succession to MR. W. A. BULL. MR. M. O. SHORT, B.Sc., A.M.I.Mech.E., Assoc. M.C.T., is now assistant superintendent of the department. Following the transfer of MR. S. A. GHALIB to be group leader of the A.E.I.-John Thompson industrial atomic-energy group, the Metropolitan-Vickers Co., have appointed MR. R. H. KELSALL, B.Sc. (Eng.), to be assistant chief electrical engineer, electronic control engineering department.

MR. L. F. SOUTHORN has been appointed manager of the Sheffield office of C. A. Parsons & Co. Ltd., Heaton Works, Newcastle-upon-Tyne, 6.

MR. C. WATTS, B.A., B.Sc., has been appointed sales manager (foundry) of the Distington Engineering Co. Ltd., Workington.

MR. D. C. NEILLANDS, M.A., LL.B., has been appointed assistant secretary to the North of Scotland Hydro-Electric Board.

MR. H. B. MELLOR has been transferred to the power and apparatus side of the business of the British Thomson-Houston Co., Ltd., Rugby, and will operate chiefly in the Potteries area. MR. R. G. MILLS has been appointed a power engineer to the company's Sheffield office. MR. J. NICHOLSON, B.Sc., A.M.I.E.E., has been appointed to the firm's Manchester office as a power sales engineer.

COMMERCIAL

A new company, R. L. ENGINEERS LTD., has been formed by the ROOTES GROUP and R. A. LISTER & CO. LTD., Dursley. The intention of the board is to ensure that overlapping in the uses of Diesel engines in the industrial, electrical, locomotive and marine fields, can be eliminated and the most effective engineering and selling costs obtained. Its initial action will be to modify and market the T.S. 3 Diesel engine, made at the Tilling-Stevens Maidstone Works of the Rootes Group for the above applications. SIR WILLIAM ROOTES, K.B.E., is chairman of the new company and the other directors are SIR REGINALD ROOTES, SIR PERCY LISTER, MR. A. CECIL LISTER, MR. B. G. ROOTES and MR. W. GARNER. The general manager is MR. R. T. BEAZLEY.

The name of EMITRON TELEVISION LTD., has been changed to E.M.I. ELECTRONICS LTD. The new company will be a controlling and co-ordinating company and will absorb as subsidiary companies, the three existing companies, E.M.I. ENGINEERING DEVELOPMENT LTD., E.M.I. FACTORIES LTD., and E.M.I. RESEARCH LABORATORIES LTD. The directors are MR. J. F. LOCKWOOD, MR. L. J. BROWN, MR. G. E. CONDCLIFFE, MR. C. METCALFE, MR. J. B. STEVENSON, and MR. S. J. PRESTON. The manager is MR. W. C. MORGAN.

GEORGE RICHARDS & CO. LTD., manufacturers of machine tools, Broadheath, near Manchester, have appointed ALFRED HERBERT LTD., Edgwick Works, Coventry, sole distributors of their products throughout the world.

ASSOCIATED BRITISH OIL ENGINES (EXPORT) LTD., and NATIONAL OIL ENGINES (EXPORT) LTD., subsidiary companies of the BRUSH GROUP LTD., have appointed FIRMA WILHELM RUMP, GERTRUDENSTRASSE, 11, Hamburg, 1, to be their shipyard representatives.

GRIFFIN & GEORGE LTD., announce the formation of a new company, GRUNDY EQUIPMENT LTD., in close association with GRUNDY (TEDDINGTON) LTD. This step has been taken to meet the growing demand for all-metal unit furniture and service pipe work for laboratories. The directors of the new company are MR. S. W. GRUNDY, MR. L. J. WEST, MR. A. G. RAMSEY, C.B.E., B.Sc.(Eng.) and MR. D. R. MAUCHEL (Secretary), all of Grundy (Teddington) Ltd., and MR. N. MCKINNON WOOD, B.A., MR. N. H. G. TREPTE and MR. A. E. LAMBERT, all of Griffin & George Ltd.

THORN ELECTRICAL INDUSTRIES LTD., have purchased nine acres of land at the junction of Great Cambridge Road and Southbury Road, Enfield, Middlesex, for the erection of factory and warehouse buildings.

In addition to the recent acquisition of KEETON SONS & CO. LTD., Sheffield, the FIRTH CLEVELAND GROUP have purchased LANDMASTER LTD., Hucknall, Nottingham. Other companies in the Firth Cleveland Group include SIMMONDS AEROCESSORIES LTD., THE FIRTH CO. LTD., BRITISH LEAD MILLS LTD., STENOR LTD., and FIRTH-CLEVELAND (MACHINE TOOLS) LTD.

On February 1, HICKS MACHINERY LTD. moved into new premises at 26, Addison-place, Holland Park, London, W.11. (Telephone: PARk 2333-4.)

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CONTRACTS

Cargo Steamer. Glen & Co. Ltd., Glasgow, managers of the Clydesdale Shipowners Co. Ltd., have placed an order with the BURNTISLAND SHIPBUILDING CO. LTD., for a cargo steamer of 2,700 tons deadweight. The vessel will be built by the firm's associated company, ALEXANDER HALL & CO. LTD., Aberdeen. She is designed for the transport of bulk and general cargoes including timber, and will have a length, between perpendiculars, of 275 ft., a breadth of 44 ft., and a depth moulded of 19 ft. 9 in. The propelling machinery will be fitted amidships and will comprise a double compound-type superheated-steam engine to develop 1,450 i.h.p.

Continuous Strip Galvanising Equipment. Richard Thomas and Baldwins Ltd., have placed an order, valued at £600,000, for the supply of continuous steel strip-galvanising equipment at their Ebbw Vale Works, with the HEAD WRIGHTSON MACHINE CO. LTD., Middlesborough. The equipment which will operate the Armco Sendzimir process under licence from the Armco Steel Corporation, has a potential annual capacity of 60,000 tons of galvanised sheet. The line, as it is termed, will be nearly 700 ft. long and is designed to receive coils of steel strip up to 48 in. wide and 30,000 lb. in weight and to produce up to 10 tons of galvanised

sheet per hour. After uncoiling, the strip is passed through several machines preparatory to entering a series of furnaces in which the material is cleaned and heat treated. After passing through the zinc bath the strip goes on to the cooling and finishing equipment, after which it is levelled, oiled and cut into lengths which are piled automatically ready for dispatch.

Transport Aircraft. The de Havilland Aircraft Co. Ltd., Hatfield, Hertfordshire, inform us that DE HAVILLAND AIRCRAFT OF CANADA LTD., Toronto, have received an initial order from the United States Government for 84 D.H.C. 3 Otter special-purposes utility-transport aircraft for the United States Army. The undercarriage can be equipped with wheels, floats, or skis, and the aircraft has a PRATT AND WHITNEY 600-h.p. Wasp engine.

Glass Evaporation Equipment. Q.V.F. LTD., Stone, Staffordshire, have received an order from a German firm for large-scale evaporation equipment for the pharmaceutical industry. The English firm believe this to be the first British industrial glassware to be exported from this country to Germany.

Power-Station, Transforming-Station and Transmission-Line Equipment. Contracts have been placed by the British Electricity Authority, during January, for power-station, transforming-station and transmission-line equipment, amounting, in the aggregate to £2,341,380. The principal contracts include: for Marchwood power station, near Southampton: structural steelwork, with ALEX. FINDLAY & CO. LTD. For Castle Donington power station, near Derby: 3,300-volt indoor air-break auxiliary switchgear, with the BRITISH THOMSON-HOUSTON CO.LTD. For Drakelow "B" power station, Burton-on-Trent: A 125 MVA 13·8—295 kV generator transformer, with the BRITISH THOMSON-HOUSTON CO. LTD. For Willington "A" power station, near Derby: 12 auxiliary transformers, with the YORKSHIRE ELECTRIC TRANSFORMER CO. LTD., and four booster and four boiler-feed pumps, with MATHER AND PLATT LTD. For Wakefield power station: two natural-draught cooling towers, with the DAVENPORT ENGINEERING CO. LTD. For Capenhurst substation, Cheshire: nine 10 MVA 132—3·3 kV transformers, with FERRANTI LTD. For Dunston substation, near Newcastle-upon-Tyne: a 75 MVA 133—66 kV main transformer and a 140 kVA auxiliary transformer, with FERRANTI LTD. 132 kV overhead transmission-line equipment for linking Rochdale, Kearsley and Rawtenstall, with W. T. HENLEY'S TELEGRAPH WORKS CO. LTD.

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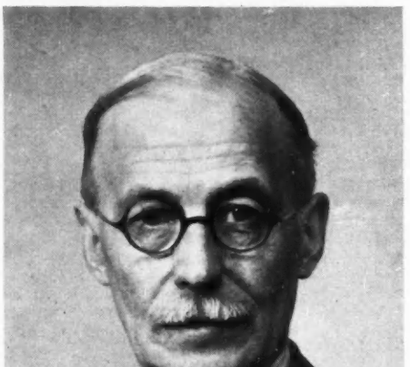
Obituary

SIR MAURICE E. DENNY, BT., K.B.E.

A Scientific Shipbuilder

It is with very great regret that we record the death on February 2 at his home in Stirlingshire, of Sir Maurice Denny, Bt., K.B.E., until recently chairman, and subsequently President of the shipbuilding and marine-engineering firm of William Denny and Brothers, Limited, Dumbarton, with whom he had been associated for practically the whole of his professional life, and one of the most scientifically-minded shipbuilders of his day. He was 68 years of age.

Maurice Edward Denny was the eldest son of Sir Archibald Denny, the first baronet, and grandson of Peter Denny, one of the brothers who, with the original William Denny, founded the firm in 1844. He was born in Dumbarton on February 11, 1886, and received his general education at Tonbridge School. The next seven years he spent abroad, the first two in Switzerland, the third in Germany, and the remaining four in the United States, where he studied naval architecture under Professor C. H. Peabody at the Massachusetts Institute of Technology and graduated with the degree of Sc.B. (Bachelor of Science). To gain practical experience of shipbuilding he then entered the shipyard of William Doxford and Sons, Limited, at Sunderland, before returning to Dumbarton to join the staff of the Denny yard. In 1911, he was made a partner in the firm. During the 1914–18 war he served in the Machine Gun Corps. Resuming his place in the firm, he was made a director in 1918, when it was converted into a limited company, and became vice-chairman two years later. In 1922, he succeeded his uncle, Colonel John M. Denny, as chairman and held that office for 30 years, retiring from it at the end of 1952, in favour of Mr. Edward L. Denny, and assuming that of President.



The late Sir Maurice Denny

Sir Maurice, who was awarded the C.B.E. in 1918, for his work in the first World War and the K.B.E. in 1946, for his work in the second, succeeded to the baronetcy in 1936, on the death of his father. In his direction of the affairs of his company, his scientific bent was constantly exhibited. Like his father, he took a keen interest in experiment-tank work and in anything that promised improved accuracy in design or the measurement of performance. He devoted much time to experiments with the Denny-Johnstone and Denny-Edgcumbe types of electrical torsionmeter and, on what has proved to be his last intervention in a discussion at the Institution of Naval Architects—at Torquay, in September, 1954—he recounted some of these early experiences; with the remark, which in retrospect seems almost a premonition—that the story was one that he had not told before, and probably would never tell again. Soon after he became chairman of his firm, he delivered a paper on his patented system of "Vane-Wheel Propulsion" before the Institution of Engineers and Shipbuilders in Scotland; a method which employed two large slow-running propellers or "vane wheels," only partly immersed, and was intended for use with shallow-draft river craft. This was a type of vessel in which he was particularly interested, as he was a director for many years of the Irrawaddy Flotilla Company.

This connection with the Irrawaddy was one of several commercial interests that Sir Maurice maintained, outside of the Leven shipyard. He was for many years a director, and eventually chairman, of the British and Burmese Steam Navigation Company (probably more widely known as the Henderson Line), and a director of the Union Bank of Scotland, of the India General Navigation and Railway Company, of Guest Keen and Nettlefolds, Limited, and of Lloyd's British Testing Company. In the organisations more closely connected with shipbuilding he was a prominent figure, having been chairman of the Technical Committee of the British Corporation Register of Shipping and Aircraft, prior to its amalgamation with Lloyd's Register of Shipping; President, in 1935, of the Shipbuilding Employers' Federation; and, in 1940, of the Shipbuilding Conference. He was one of the founders of the Air Registration Board, and, for some years, its chairman; and chairman, until comparatively recently of the Research Board of the British Shipbuilding Research Association, in which capacity he presented to the Institution of Naval Architects, in 1951, the first paper on the resistance trials with the former paddle steamer Lucy Ashton. From 1937 onwards, for a number of years, he represented that Institution on the General Board of the National Physical Laboratory and on the advisory committee of the William Froude Tank.

Sir Maurice's support of professional institutions was active and practical. He was a member for more than 40 years of the Institution of Engineers and Shipbuilders in Scotland, which made him an honorary member in 1950; an honorary Vice-President of the Institution of Naval Architects; President, in 1935, of the Institute of Marine Engineers, as his father and grandfather had been before him; a member of the Institution of Civil Engineers; and President, in 1943–44, of the Junior Institution of Engineers, in which office also he was following his father. Among his other interests—apart from the relaxations of golf, ornithology and ship-model making, in the last of which, especially, he was a craftsman of the highest quality—was the study of aeronautics, stimulated, no doubt, by the fact that, when he was a young man, his firm constructed the first helicopter to leave the ground under its own power. The project was soon abandoned under pressure of other work, though the firm were concerned in the construction of more orthodox aircraft during the recent war; but it was a machine embodying a number of ingenious features, not the least being that the tubes of the framework were made of paper, rolled helically on mandrels. Undoubtedly, however, the most successful scientific development with which he was associated was the Denny-Brown stabiliser for ships, in which he and Messrs. Denny collaborated with Sir William Wallace and Brown Brothers, Limited, of Edinburgh. On that account, if no other, his name is assured of permanent remembrance, not only by shipowners, shipbuilders and his friends, but by seafarers for generations to come.

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We regret also to record the deaths of:

SIR GERALD EDWARD CHADWYCK-HEALEY, Bt., C.B.E., D.L., at his home at Straiton, Ayrshire, on February 2, in his 82nd year. Sir Gerald, a former chairman of Morgan Brothers (Publishers), Ltd., proprietors of our contemporary, *The Engineer*, and other technical journals, was the grandson of Mr. Edward Charles Healey, the founder of The Engineer, Ltd. Sir Gerald joined this firm in 1895, and was appointed a director in 1904. In 1919, he succeeded his father, Sir Charles Chadwyck-Healey, the first baronet, K.C.B., K.C., D.L., as chairman of the company and when amalgamation with Morgan Brothers Ltd., took place in 1929, Sir Gerald was appointed chairman of the new company. He continued to occupy this position until March, 1948, when he retired. He finally retired from the board on July, 1951. Sir Gerald's brother, Mr. Oliver Chadwyck-Healey is the present chairman of Morgan Brothers (Publishers), Ltd.

MR. JOHN CHARLES TELFORD, O.B.E., M.I.C.E., M.I.Struct.E., at his home at Pedmore, near Stourbridge, Worchestershire, on January 21, at the age of 72. After receiving his training with the Tees-side Bridge and Engineering Co., Ltd., Middlesbrough, Mr. Telford was for 13 years with Dorman, Long & Co., Ltd., finally as manager of the constructional department. In 1919, he became general manager of Braithwaite & Co., Engineers, Ltd., and was for a number of years a director of the firm.

MR. JAN KACIREK, B.Sc. (Eng.) (Lond.), A.M.I.C.E. who was 26 years of age, was a passenger in the West African Airways Corporation air liner which crashed in the bush, while on a flight from Enugu to Calabar, with the loss of its nine passengers and crew of four. The aircraft was found on February 6. Mr. Kacirek joined the staff of Messrs. Richard Costain Ltd., public-works contractors, London, in October, 1948, and had been engaged on works connected with the Ijora power station at Lagos, Nigeria. A month or two ago he was transferred to Costain, West Africa, Ltd., and was due to come home on leave in April next.

PROGRESSIVE RAILWAY POLICY IN THE NETHERLANDS

PRESSING ON WITH ELECTRIC AND DIESEL TRACTION

Before the war the management of the Netherlands Railways—fully nationalised from January 1, 1938—had embarked on a policy of modernisation, including electrification of the principal routes, and by 1940 16 per cent. of the total mileage of 2,060 was being worked electrically.

By the time the liberation came in 1945, however, this fine system had suffered great damage. Many locomotives and much of the rolling stock had been rendered useless, or removed with a large proportion of the overhead equipment, while stations, electrical sub-stations, bridges, tracks, etc., were in a deplorable condition. About two-thirds of the system was out of action but reconstruction was undertaken with such determination and initiative that by the end of 1947 a moderately satisfactory service was being operated, although arrears of maintenance imposed numerous speed restrictions.

SCIENTIFIC APPROACH

Progress has been continuous since. The paper read by Mr. F. Q. den Hollander, President of the Netherlands Railways, before the Royal Society of Arts on February 2, not only showed how great a task has been accomplished in the last nine years but in how scientific a manner the whole question of the future of railed transport in his country is being approached.

The Netherlands Railways, at one time worked by a number of companies, enjoyed a high reputation for efficiency and freedom from accident. They had to meet both the local requirements peculiar to a small country where there could be no long non-stop runs, and those of certain international services. The nature of the sub-soil, in many places composed of weak layers of peat and clay, influenced the design of the permanent way and set a limit to permissible speeds. It made it difficult to work point rodding, so double-wire transmission had to be used for both points and signals. The country being almost everywhere flat, good canal and road systems came early into existence. Thus the railways always had a fair amount of competition to meet. There are also numerous rivers able to carry considerable traffic; in 1953 waterways accounted for 53 per cent. of the inland goods transport, while the railways handled 30 per cent. and the roads 17 per cent.

The density of population, now about 800 per square mile compared with 540 in the United Kingdom, and greatest in the west where the large cities are relatively close together, gives rise to a high level of mobility and it is of interest to note that while the population doubled itself between 1878 and 1938 passenger transport increased no less than 34 times. An ever-growing demand on all types of transport is being felt, and the railways, which form a separate corporate entity under an obligation to pay their way, are seeking by every possible means to offer thoroughly attractive services at reasonable rates, while utilising every resource of modern skill and research to reduce costs to a minimum.

ROAD AND RAIL

This has involved consideration of a number of factors, one of the most important being the trend towards greater industrialisation and consequent changes in the types of traffic offering. As elsewhere, some routes have been closed entirely and others to passenger traffic only, but there is a limit to this negative method of improving the railway budget. In many cases routes not profitable in themselves are of great importance to the general efficiency of the system. The railways control a number of subsidiary omnibus undertakings and have been able to arrange alternative services to the best advantage where rail communication has had to be abandoned. Similarly in the case of goods traffic they operate through an important subsidiary concern.

As regards passenger services, the system can be looked on as a very large suburban one, requiring fast trains over relatively short distances with numerous stops. Rapid acceleration and high average speeds are essential. For this and other reasons, such as greater convenience in handling at termini and obtaining maximum user of rolling stock, it has been decided to use electric or Diesel-electric traction exclusively. The country cannot now produce sufficient coal for home consumption and railway needs must be reduced to a minimum. Higher speeds necessitate a considerable strengthening of the track and its foundations, while a number of river bridges originally built to carry only a single line, including the celebrated bridge at Moerdijk, 1,100 yards long, are being strengthened and rebuilt for double lines, thereby eliminating tiresome bottlenecks.

ELIMINATING LEVEL CROSSINGS

Many stations are being rebuilt and equipped with power signalling. In some towns the whole line is being raised to eliminate level crossings, very numerous in the Netherlands. These originally had watchmen who could serve as signalmen, but the introduction of automatic warning signs and barriers enabled staff to be dispensed with and automatic signalling to replace manual working. A beginning was made with this some years ago, but the work is to be pushed forward and the principal routes are all to have automatic signalling within ten years. A new system of light signal aspects, presenting some novel features, has been adopted.

While most of the services will be operated on a fixed time-table plan, by multiple-unit stock, whether electric or Diesel, electric locomotives are to be used for long runs and, of course, for goods trains, operated as a rule at night.

The capital for this remarkable programme has been made available by the State. Certain difficulties have retarded its execution to some extent, but when it is completed the Netherlands will possess an exceptionally fine railway system. Mr. den Hollander's unique experience of the work will be of great value to the British Transport Commission's technical development and research committee, which he has recently accepted an invitation to join.

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NEW SCOTTISH HYDRO-ELECTRIC SCHEMES

The North of Scotland Hydro-Electric Board have published particulars of two schemes for increasing electrical output in Scotland. One, the Loch Glashan scheme, is a new project, and the second is an entension to the Tummel Valley scheme.

For the first, it is proposed to utilise the waters of Loch Glashan to produce 17,600,000 units of electricity annually. The loch is in the county of Argyll and lies in the hills behind the hamlet of Lochgair on Lochfynside. It has a natural catchment area of four square miles, but diversion aqueducts will be built to draw the rainfall from a further 20½ square miles. The generating station will be on the shores of Loch Gair and will have an installed capacity of 4·2 MW at a head of 356 ft. Discharge will be into the loch. The scheme will require a dam at the outlet of Loch Glashan, which will be 1,100 ft. long and 45 ft. high. Output from the station will help to meet the growing demands of the Kintyre and Knapdale areas.

The Tummel Valley additions scheme will add about 32,700,000 units a year to the output of the existing schemes on the Rivers Tummel and Garry, in Perthshire. Two new power stations will be built, one at Loch Ericht at the outlet of the existing tunnel from Loch Garry, with a capacity of 1·5 MW, and the other in Glen Truim at the head of the aqueduct leading from Allt Cuiach to Loch Ericht. This second station will have a capacity of 2·4 MW. Also included with the scheme are diversions to several burns and an enlargement of the aqueduct from Dunalastair reservoir to the Tummel Bridge power station.

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SEVENTH BRITISH ELECTRICAL POWER CONVENTION

"Electricity and the Future" to be Discussed

The preliminary programme of the seventh British Electrical Power Convention, which is to be held at Brighton from Monday, June 27, to Friday, July 1, has been issued. The theme will be "Electricity and the Future", and the papers presented will give authors an opportunity to review the progress in various fields and probably to forecast future developments. As in former years the British Electrical Development Association will be responsible for an electrical exhibition, which will be held in the Sports Stadium, West Street, Brighton.

Proceedings will open with the official inauguration of the exhibition on Monday evening, June 27, by the President, Sir Harry Railing. On Tuesday morning, June 28, there will be a meeting in the Dome at which a civic welcome will be given to the Convention by the Mayor of Brighton and Sir Harry Railing will deliver his presidential address. On Wednesday morning, June 29, a paper on "The Generation of Electricity in Britain (Ten-year Forecast)" will be presented by Mr. J. Eccles for discussion and in the afternoon of the same day three papers on "The Electrical Industry as a Career" will be read. These will be "The Electricity Supply Industry," by Sir Henry Self; "The Manufacturing Industry," by Mr. S. E. Goodall; and "The Installation Contracting Industry," by Mr. R. A. Marryat.

On Thursday morning, June 30, two papers on "Electricity and the Industrial Future" will be considered. One of these will be on "The Use of Electricity in the Steel Industry," by an author to be announced, and the other on "The Use of Electricity in the Coal Industry," by Mr. B. L. Metcalf. In the afternoon of the same day there will be another two papers dealing with the same general subject: one on "The Use of Electricity in the Chemical Industry," by Mr. G. Nonhebel, and the other on "The Use of Electricity in the Catering Industry," which will be presented by Mr. F. A. Rogers. On Friday morning, July 1, there will be, as in previous years, an electrical forum and this will be followed by the annual general meeting.

The annual dinner will be held on Thursday evening, June 30, and there will be a number of other social functions.

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INDEX TO "ENGINEERING"

Volume 177 now ready

The Index to Volume 177 of ENGINEERING (January-June, 1954) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36, Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

WORLD POWER CONFERENCE

1956 *Plenary Meeting to be held in Vienna*

The final text of the technical programme of the Fifth Plenary World Power Conference, to be held at Vienna from June 17 to 23, 1956, has now been issued. The main theme of the meeting will be "World Energy Resources in the Light of Recent Technical and Economic Developments," and the papers to be presented will be classified into five main divisions, each of which will be further sub-divided into several sections.

The first main division will cover "The State and the Development of Power Production and Utilisation in Individual Countries," the second will be concerned with "The Preparation and Conversion of Fuels," the third will relate to the "Utilisation of Primary Sources of Energy," the fourth will deal with the "Purification of Waste Water and Waste Gas in the Production and Use of Energy," and the fifth division will be devoted to papers on "International Collaboration in the Production and Use of Energy."

Individual papers will not be read at the Conference in order that the time available may be devoted exclusively to discussions. Several reporters, however, will be appointed who will summarise the papers in the various sub-divisions and sections and suggest topics for discussion. These summaries, as well as the individual papers, will be printed and circulated among participants in advance so as to give sufficient time for review and study. It is recommended that the papers should be in German, English or French, which have been adopted as the three working languages for the Conference.

Papers can only be submitted through the National Committees and National Representatives of the World Power Conference; the British National Committee have appointed a committee to make arrangements for the preparation of papers in this country. The chairman of this committee is Mr. J. Eccles, C.B.E., and the members comprise Mr. J. R. Beard, C.B.E., Mr. F. N. Beaumont, Sir John Cockcroft, F.R.S., Sir Walter Drummond, Mr. Henry F. H. Jones, M.B.E., Mr. H. G. Nelson, Mr. J. A. Oriel, C.B.E., Dr. A. Parker, C.B.E., Mr. V. A. Pask, C.B.E., Mr. J. S. Pickles, and Mr. K. T. Spencer, C.B.E.,

National Committees have been requested to furnish to the secretariat of the Austrian National Committee a list of the titles and authors of papers to be submitted at the Conference as soon as practicable and, in any case, not later than April 30, 1955. Completed papers must reach the secretariat in Austria not later than September 30, 1955.

Communications intended for the British Papers Committee should be addressed to the secretary, British National Committee, World Power Conference, 201–2, Grand Buildings, Trafalgar-square, London, W.C.2. All other communications and inquiries concerning the Fifth World Power Conference should be addressed to the Oesterreichisches Nationalkomitee der Weltkraftkonferenz, Vienna 1, Schwartzenbergplatz 1, Austria.

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PAPERS BY YOUNG ENGINEERS

As previously announced, the annual meeting of the British Association will be held this year in Bristol from August 31 to September 7, and, as is now customary, one of the sessions of Section G (Engineering) will be allocated to the reading and discussion of papers by young engineers or engineering students. Manuscripts of suitable papers, which should be short and should preferably deal with the author's own work, are now invited. Particulars can be obtained from the Recorder of Section G, Professor W. Fisher Cassie, King's College, Newcastle-upon-Tyne, 1.

UNWASTED WOOD WASTE

SUPPLIES AND USES

Considerable wood waste occurs in the production and utilisation of timber. Some of it, in the form of stumps, lopping tops and branches, and of felling damage during forestry logging operations, is unavoidable and is estimated to account for about 23 per cent. of the total. It is during the sawing and other manufacturing processes to convert the tree into sawn timber and joinery, however, that the biggest losses occur, estimated to be :—

	Loss, per cent.
Bark	8
Slabs, edgings and trimmings	17
Seasoning and drying	4
Re-manufacture (converting large size boards and battens to smaller dimension stock)	3
Saw-kerf (sawdust)	10
	42

Taken together these two figures make a total loss of 65 per cent. from the original standing tree.

Generally speaking, the forest waste is of little use other than locally as fuel, but the off-cuts, chips and sawdust waste produced (in the ratio 45 : 15 : 40 per cent.) during sawmilling and woodworking find certain markets if these are accessible. Most of the wood waste accumulates in large industrial areas or near the big ports. As hauls of above 50 miles are uneconomic due to the bulky nature of the material, its distribution tends to be patchy over the country as a whole.

It is estimated that over 200,000 tons of wood waste are produced annually in Great Britain; of this, about 30,000 tons comes from the London area.

Offcuts, Edges and Trimmings.—These can be used for small dimension stock, toys and ornaments, or, more commonly, it is reduced by pulverising mills to woodchips. As chips, the waste can readily be converted, with the addition only of a synthetic-resin binder, to building boards by use of automatic presses and plattens. Recently, the "Bartrev" process* has been used to convert it into a continuous strip of chipboard on the paper-mill principle. These chipboards are made by four firms in the United Kingdom: "Plimberite" (by British Plimber, Limited, Albert-embankment, London, S.E.11), "Bartrev" (Vere Engineering Company, Limited, Marks Tey, Essex), "Lydneyboard" (jointly owned by Wm. Mallinson and Sons, Limited, and J. Glikstens, Limited, Stratford, London, E.), and "Weyroc" (The Airscrew Company and Jicwood, Limited, Weybridge). The last-mentioned firm also market their material in small sizes suitable for flooring. A supply of at least 80 tons of chips per week at each factory is essential for the economic production of chipboard in this country. Four other makes of board are being imported—two from Germany, where there are six factories, one from Belgium, and one from Canada.

Production, which has been commenced only since the war, has expanded rapidly and is about 15 million square feet annually in the United Kingdom compared with 25 million square feet in Germany. The imports are negligible but the United Kingdom export is about 2 million square feet per year. The material is very competitive in price with plywood and, to a lesser extent, with softwood timber.

Sawdust and Wood Flour.—Excess sawdust which cannot be sold locally is usually destroyed by burning, although some mills use it as a furnace fuel for heating and power. This is not greatly favoured, however, due to the frequent need for stoking and other technical difficulties. Apart from a small amount processed by distillation for wood alcohol, etc., the remainder finds markets for such uses as soil improvers (compost), deep litter for poultry houses, floor-sweeping compounds, leather dressing and fur cleaning, gas purification, fish curing, packing fragile goods, hollow-wall insulation and wood flour, but none of these industries absorb sufficient to decrease appreciably the quantities constantly accruing at large sawmills.

The consumption of wood flour, which is sawdust specially reground to a finer consistency, is about 40,000 tons per annum (home production 34,000 tons, the rest imported) and has become widely used as an ingredient in the manufacture of plastics goods such as radio cabinets, telephone receivers, moulded ornaments, utensil handles, electrical fittings, etc. The percentage of incorporated wood flour can be as high as 60 to 70 per cent.; a large percentage lowers production costs, but will decrease the surface lustre and smoothness of the article. Wood flour is also used in the manufacture of, amongst others, linoleum, roofing felt, wallpaper, "plastic" wood, storage-battery cases, hand cleansers, explosives and carriers for horticultural insecticides.

* This process was fully described in ENGINEERING vol. 175, page 748 (1953).

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ELECTRONICS IN INDUSTRY AND COMMERCE

A conference on "Electronics in Industry and Commerce," which was organised by the South Wales Electricity Board, was held in the Patti Pavilion, Swansea, on Wednesday, Thursday and Friday, February 2, 3 and 4; and will be repeated at the Drill Hall, Dumfries Place, Cardiff, on Wednesday, Thursday and Friday, February 16, 17 and 18. On each day three films, showing the general and particular applications of electronics were, or will be, shown. These were followed by a talk by Mr. W. P. Warren, Assistant Chief Commercial Officer of the Board, to whom the arrangements of the conference were largely due; and by a "Brains Trust," formed by representatives of electrical manufacturing firms. There was also an exhibition of electronic equipment, a feature of which was the large number of working models.

On Wednesday, February 2, the attendance was limited to the staffs of the Board's western and west central sub-areas, while invitations to be present on the other two days were issued to industrialists in the same districts, as well as to teaching organisations and members of the Electrical Contractors' Association. Similar arrangements will be made at Cardiff, and in addition, the new electronic laboratories of the College of Technology and Commerce in Cathays Park, will be opened to visitors.

Some 80 per cent. of the electrical consumption in the area served by the South Wales Electricity Board is industrial. The problem of its efficient utilisation is therefore important, a corollary being that works managers, production engineers and others in similar positions should be kept informed of the latest techniques and equipment. It was with this end in view that the Board organised a conference on power factor in 1954, which was attended by some 600 industrialists, and is now followed by this year's gathering, the success of which should be even greater.

One reason suggested for this success is that the scope of the conference is limited and specialised, so that a concentration of effort, which leads to better results than a general exhibition, is possible. It is hoped that in future such subjects as welding, process heating and lighting will be dealt with, forming a valuable method of educating the public.

Book Reviews

INSTABILITY IN MOTOR-CARS, AIRCRAFT AND SUSPENSION BRIDGES

L'Instabilité en Mécanique: Automobiles-Avions-Ponts Suspendus. By Y. ROCARD. *Masson et Compagnie, 120 Boulevard Saint-Germain, Paris (6e).* (1,200 francs.)

This is the first of a new series of monographs designed to afford an opportunity for the presentation of the results of personal investigations on topics that lie outside, or cut across, the traditional subdivisions of the subject matter of science. Despite their vital importance, problems of dynamical instability are seldom dealt with in conventional mechanics courses.

Professor Rocard's interest in the subject dates from 1933 when he was consulted after a train derailment on the Cherbourg line. His investigations resulted in the publication of a two-volume work in 1936, in which he analysed the causes of the accident and suggested means for avoiding their recurrence. Since then he has extended his researches to throw new light on the causes of instability in motor cars, aeroplanes and suspension bridges. Some of his more general conclusions are contained in his *Dynamique Générale des Vibrations* (reviewed on page 4 of our 169th vol., 1950).

In the present volume he confines his attention to the self-excited oscillations that are liable to arise in a motor car in motion, an aeroplane in flight and a suspension bridge acted upon by a wind. In order to derive numerical values for the critical velocities and frequencies defining the onset of instability, certain simplifying assumptions are inevitable, but those adopted approximate sufficiently closely to conditions encountered in practice to permit the resulting numbers to be confronted with, and checked against, observational data. When the displacement of a system, to which a transient or periodic disturbing force is either accidentally or intentionally applied, increases progressively with time the system becomes unstable. In the case of electrical oscillations this is usually due to the circuit exhibiting a negative resistance, and there has been a tendency to regard this as the main determining cause of mechanical instability. Professor Rocard however discovered that certain forces, in quadrature with the displacement and not derivable from a potential, are capable of re-injecting energy into the system and so inducing instability. Moreover, he showed that, when either positive or negative resistances are present, the tendency to instability is invariably enhanced. This striking property, termed by its author "instability by the confusion of two proper frequencies," serves as the guiding principle throughout the exposition. It is introduced in the third chapter, following preliminary remarks on the simple harmonic oscillator and a discussion of conservative systems with two degrees of freedom, illustrated by a consideration of the influence of alternative types of springing on the riding qualities of cars. Simple examples of the application of this principle are then given, including a spring-mounted flat plate in a wind stream, an articulated carriage and the tricycle landing gear of an aeroplane. The first part ends with a discussion of further factors affecting the road-holding qualities of cars, such as "shimmy" and the lateral flexibility of the tyres.

The second part contains an excellent general account of the causes of instability in suspension bridges, together with a detailed analysis of the destruction of the Tacoma bridge in 1940. This was caused by a low-frequency flutter set up by a lateral wind of only about 30 m.p.h. Fortunately the whole course of events was filmed and a number of "stills" from this spectacular record are reproduced. The various possible modes of oscillation of such a structure are considered and failure is shown to be attributable to a coupling between the flexural and torsional modes due to the intervention of aerodynamic forces. Using the available data relating to the Tacoma bridge, and assuming reasonable values for other parameters appearing in his equations, Professor Rocard is able to deduce a value for the critical wind velocity within 10 per cent. of that observed and to put forward some notable recommendations for the guidance of bridge designers.

Part III, dealing more briefly with aeroplane wing flutter, longitudinal stability in aircraft and related matters, is based on practical experience dating back to 1936.

Apart from the intrinsic interest of his subject there are several reasons why Professor Rocard's exposition will particularly appeal to engineers, among them being his adoption of a general physical principle that enables the majority of problems in dynamical instability to be given a unified treatment, his avoidance of unprofitable algebra by judicious attention to orders of magnitude and his skill in obtaining numerical results in substantial agreement with experimental findings. This fascinating and illuminating monograph brilliantly inaugurates a new series.

Theory and Design of Steam and Gas Turbines. By JOHN F. LEE. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.;* and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (64*s.* 6*d.*)

Although the design of both steam and gas turbines depends ultimately on the same thermodynamic and mechanical principles, the conditions of operation differ so widely that no very close analogy is possible. The author of the present volume, who is on the professorial staff of the North Carolina State College, has therefore been practically compelled to treat them independently, confining his individual chapters mainly to one kind of machine or the other. About half of the book is allocated to each, the chapters being intermingled so as to keep corresponding subjects together. The only really common ground is an exposition of the fundamental principles of thermodynamics, which contains, among the more usual features, an ingenious deduction from the accepted "Laws" that the absolute zero of temperature must be for ever unattainable.

So far as steam turbines are concerned, the descriptive matter and illustrations are exclusively confined to American machines, the Ljungstrom turbine being dismissed in a few lines as "of no particular interest in the United States." One does not gather that transatlantic practice in the design of either complete machines or their details is in any way ahead of our own, and in some cases it might appear to be less advanced. The theoretical treatment is well and fully done, but the greatest interest of the book will undoubtedly be found in the chapters dealing with the newer field of the gas turbine.

In these, the various types of gas turbine that have come into commercial use and the cycles on which they operate are first described. Then, in a chapter on elementary gas thermodynamics, such things as the Mach and Reynolds numbers, the Fanno and the Rayleigh lines, the phenomena of shock waves and general aerofoil theory are discussed. Centrifugal and axial compressors are given chapters to themselves. In demonstrating the use of dimensional analysis in the design of the former type the author strangely allots to temperature the dimensions of velocity squared. So far as temperature can be thought to have any meaning in connection with the state of individual molecules, this point of view might be tenable, but it certainly cannot be justified when considering gaseous or other matter in bulk, for it would lead among other things to the conclusion that the entropy of any substance must have the dimensions of mass alone—a consequence that seems to have escaped notice. In another chapter the thermo-chemistry and the mechanics of combustion are dealt with, and the design of heat regenerators also has a special chapter. Then follow discussions of the design of gas-turbine plants for stationary and aircraft duties, and finally an appendix comprising tables of the thermodynamic properties of air and combustion products, with a summary of the steam tables of Keenan and Keyes.

The book is well written and the presentation of its subjects is a refreshing change from the usual treatises on thermodynamics, while a further attraction to practical engineers is the use of the ordinary British units throughout. It is nominally addressed to students, for whom questions (without answers) are provided at the ends of chapters, but to derive full benefit from it the reader needs not only a fair mathematical knowledge, but also some familiarity with the kind of machinery concerned. Its greatest usefulness will therefore be to turbine designers and especially to those entering the field of gas turbines, to whom it can be certainly recommended.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Underground Electric Trolley Locomotive. NATIONAL COAL BOARD, Hobart House, Grosvenor Place, London, S.W.1. Description of the first electric trolley locomotive installation in a British colliery (Sandhole Colliery). Technical descriptions of the underground conditions influencing the installation, and of the locomotive, power supply, track layout and signalling equipment. Report on the performance of the locomotive and the operating difficulties. Special Regulations were necessary under the Coal Mines Act, 1911, for this installation; these are printed as an appendix. Illustrated pamphlet, with photographs and drawings of the locomotive, mine layout and electrical installation. National Coal Board Information Bulletin No. 54/128.

Electric Lamps. THE BRITISH THOMSON-HOUSTON CO. LTD., Crown House, London, W.C.2. "Mazda" lamps for all purposes; general lighting, pearl, clear, and silverlight lamps; decorative lamps for festivities and architectural uses; infra-red heating lamps; electric discharge lamps, cold cathode, fluorescent, mercury vapour and sodium vapour; projector lamps; lamps for all photographic needs; lamps for motor vehicles, bicycles, aircraft and for many other miscellaneous applications; a selection of fittings, auxiliary gear, street-lighting lanterns and floodlights. Comprehensive illustrated catalogue for 1955, showing dimensions, lamp outlines, and efficiencies.

Modular Building. THE MODULAR SOCIETY LTD., 22 Buckingham-street, London, W.C.2. Products of companies subscribing to the Society's objective of furthering the modular system of design and construction of buildings. The modular system employs a three-dimensional cubic frame of reference and it is intended that the external dimensions of building components shall be fixed so that they readily conform with the dimensions of the system. In this way it will be possible to ease the difficulty of assembling the products of different trades and different makers. Loose-leaf catalogue.

Equipment for Spectrochemical Analysis. HILGER & WATTS, LTD., Hilger Division, 98 St. Pancras-way, London, N.W.1. Arc and spark stands for use with spectrographs in spectrochemical-analysis work. Pamphlet illustrating and describing components suitable for use with rod and flat samples and also with solutions.

Excavators and Cranes. BLAW KNOX LIMITED, 94 Brompton-road, London, S.W.3. The "BK50" basic machine fitted with appropriate ½ cub. yd. buckets for a grabbing crane, dragline, drag shovel, face shovel, skimmer, and with a leader frame and 1-ton drop hammer as a pile driver. Illustrated leaflets.

Timber Roof Trusses. AERO RESEARCH, LTD., Duxford, Cambridge. Use of "Aerolite 300," a synthetic resin glue for timber roof trusses. Illustrated technical notes.

The Engineering Outlook—5

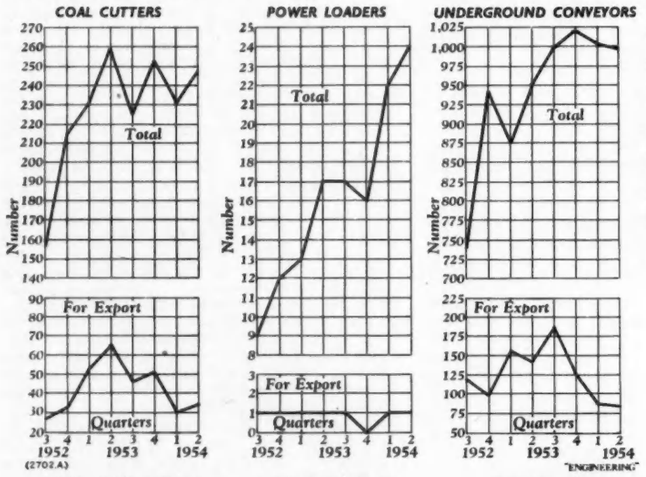
COAL AND ELECTRICITY

MINING MACHINERY, BOILERS AND HEAVY ELECTRICAL PLANT

Last year will go down in the history of the coal and electricity industries as one of achievement so far as investment in plant and equipment is concerned. The annual average planned investment target for the coal industry since 1950 has been about £53 millions at current prices. In 1952, the industry spent almost £49 millions. In 1953, the year's outlay rose to £64 millions on capital account and in 1954 it reached £83 millions. Thus by the end of 1954 the coal industry was beginning to make up some arrears of investment although much still remains to be done.

In the case of electricity, new generating capacity installed was once again at the rate of over 1,400 MW a year; the industry expects to increase this gradually to a figure of just under 2,000 MW in 1959. Last year will also be remembered as the year in which the broad pattern of national fuel and energy policy was laid down until 1960. It is a policy of expansion involving a maximum of £2,256 millions: £450 millions in coal, £366 millions, in gas and £1,440 millions in electricity. There is every prospect therefore of a sustained high demand for equipment from the coal and electricity industries for some years to come, and it is not likely that any steps which may be taken to remove inflationary pressure on the economy (such as the increase in Bank Rate to 3½ per cent. in the last week of January), will have any serious effect on the outlook for mining machinery and electrical plant manufacturers so far as the home market is concerned.

The last year has shown once again that coal in this country is likely to remain scarce for an indefinite period so long as the economy is anywhere near a state of full employment. Operating costs may well continue to increase but there is little likelihood that these increases will fail to be passed on to the consumer as long as the demand and supply position in the coal industry is in any way similar to that which obtained in the last year. Average weekly production of coal increased from 4·30 million tons in 1953 to 4·32 million tons in the first 11 months of the year, that is by less than 1 per cent. The output of saleable mined coal increased over the same period from 4·08 to 4·10 million tons but opencast coal production fell from an average weekly tonnage of 225,000 to 203,000 in the same period. Consumption, however, increased much more rapidly than total production. Weekly average inland consumption rose from 4·00 million tons in 1953 to 4·36 million tons in the first 11 months of 1954, while exports were almost unchanged from a weekly average of 268,000 tons in 1953 to 266,000 tons in 11 months of last year. The gap between production and consumption in the home market had to be made good by the importation of coal, mostly in the second half of the year, and by drawing on stocks. There has been the prospect for some time of a gradual increase in the demand for coal, and this increase has been accelerated by the recent industrial boom. Sir Hubert Houldsworth was able to point to an increase in juvenile recruitment during 1954, when he reviewed the industry's manpower position in the closing weeks of last year; however, the trend of employment at the coal face is still not satisfactory, and there is little prospect in the short run that the programme of mechanisation will enable the industry to close the gap. Coal thus continues to enjoy a seller's market.



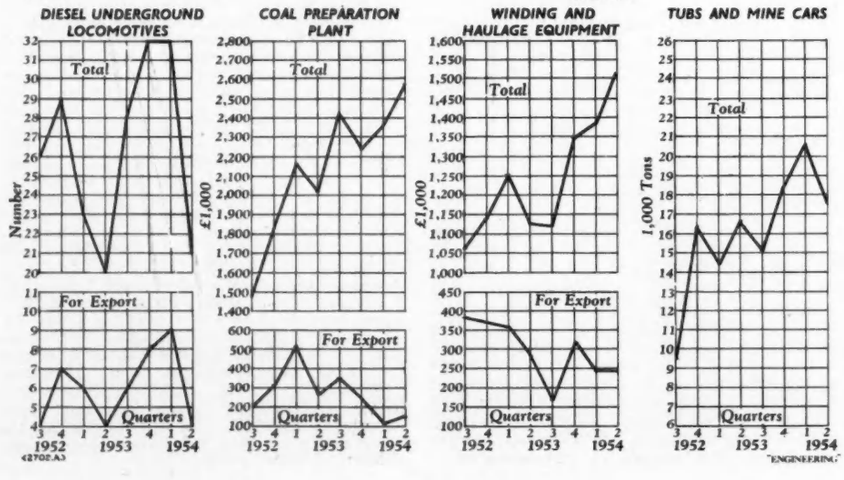


Fig. 1 Quarterly figures for U.K. deliveries of coal-mining machinery. The coal industry's investment programme has helped home sales, but exports have been disappointing.

STEADY HOME DEMAND FOR COAL MINING MACHINERY

To judge from the deliveries of coal-mining machinery to the home market in the first half of 1954, shown in Fig. 1, manufacturers have benefitted notably from the coal industry's investment programme at a time when exports have been very disappointing. As the first graph of Fig. 1 shows, there has been a steady flow of all kinds of equipment to the mines in this country, notably of power loaders. In spite of the rising demand for coal-mining machinery there is little doubt that the manufacturers could supply more if the coal industry's investment programme were further speeded up.

Among the technical developments which have made some progress during the year has been the boring for coal seams under the sea off the coasts of Northumberland and Durham. Progress has also been made with the use of a portable vacuum cleaner to control coal dust in mines and with increasing the efficiency and safety of blasting methods. But a combination of circumstances, of which the slow rate of increase in the capital investment programme is only one, goes to suggest that the experimental and development stage of technical improvements could be speeded up. The report of the Chief Inspector of Mines for 1952, which was published in January, points out that the coal produced per pound of explosives used fell from over 7 tons to 4 tons between 1940 and 1952. He does not think this serious fall of 40 per cent. over 12 years in coal produced per unit of explosive can be explained alone in terms of thinner seams. Put the other way, the large increase in explosives used per ton of coal won at the face must have increased the effort necessary and the danger involved for the industry's precious supply of face-workers. Much of the capital investment in the coal mines over the next few years will be in new sinkings. But so far as investment in existing mines is concerned, this case of the amount of high explosives used of recent years (at least until the Chief Inspector's report was prepared) is a reminder that issues other than mechanisation are now of key importance. A continued flow of equipment into existing mines is to be expected, and indeed will play a big part in raising output per man from the pits, but such equipment will go in on a selective basis. From now on it is going to be increasingly apparent that a higher standard of management in the older mines will get better results than a higher rate of investment.

FUEL EFFICIENCY AND SAVING

Dear coal is a fact with which British industry has lived for some time. As time goes on, the upward pressure on costs comes not only from the side of wages, but also from high replacement costs and depreciation charges, along with the technical fact that coal becomes yearly more difficult to extract from, on the whole, narrower seams. Fuel efficiency under these conditions (as when potential demand exceeds supply by a sizeable margin) becomes of primary interest to the coal industry and coal users alike. This may not always be so —a point to be mentioned again below. For the next few years, however, fuel conservation is of importance to the coal industry. It can hardly therefore be to the disadvantage of the mining machinery manufacturers, and the engineering industry as a whole must surely benefit from the need for fuel efficiency equipment.

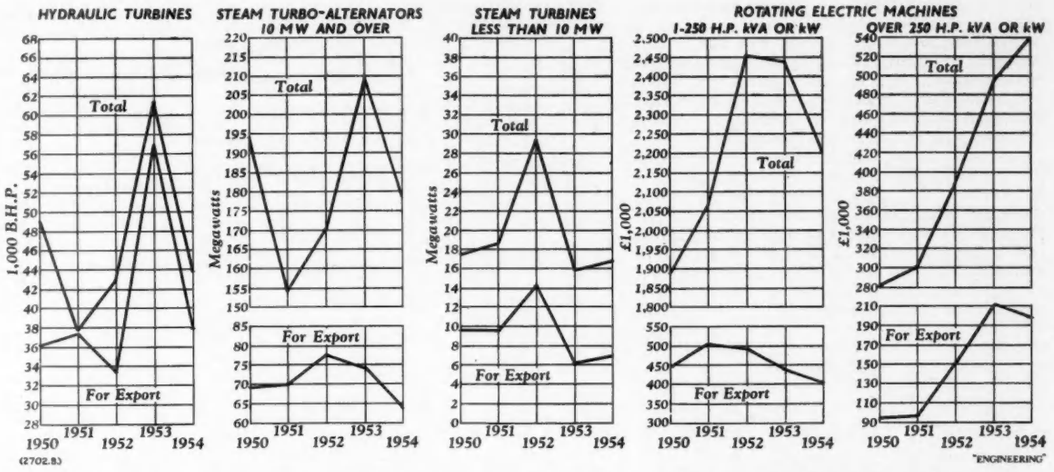


Fig. 2. Monthly averages from 1950 to 1954 (1954 based on total for 9 months) for U.K. deliveries of electrical plant and machinery. Reduced exports have affected total deliveries.

The National Industrial Fuel Efficiency Service, which established its entity separately from the Ministry of Fuel and Power last year and which is subsidised by the coal, gas and electricity industries, has set itself an ultimate target of saving 9 million tons of coal a year. It was expected at one time that the gap between potential demand and supply of coal would be 20 million tons by 1960. This is likely to be a conservative estimate given the present rate of investment and recruitment in the industry on the one hand and the possibility of sustained full employment with rising productivity (hence a rising consumption of power) on the other. The electrification of the railways under the 15-year plan announced last month might save up to 5 million tons of coal a year, the electrical generating industry is expected to save 6 million tons a year by 1960 and it has been said that the coal industry could save itself 5 million tons a year by investment in new equipment. All these figures, even though they are only approximate, suggest that a gap of 20 million tons of coal could be bridged by economy measures in industry and a modernisation programme for power generating equipment between now and about 1960. So long as the gap lasts and can be closed only by economy measures, the coal industry and those industries which supply it with equipment are sure of adequate markets. But it will not last for ever. There are straws in the wind now in the 1950's which presage changed conditions in the 1960's. If those changes should come quickly, manufacturers of mining equipment may find themselves dependent on a replacement, instead of an expansion, demand from the National Coal Board as the main outlet for certain kinds of equipment.

OIL-FIRING AND NUCLEAR POWER

One straw is the perceptible change of attitude by the British Electricity Authority on oil-firing for power stations. Only Bankside in London at present operates on oil, but dual firing equipment for coal and oil is going into the Marchwood power station in Hampshire, due for completion in 1956. It will be recalled, too, that the £1,200-millions programme for the railways is remarkable not only for its size but also for its bold break with previous railway thinking about steam traction. The steam locomotive's days are numbered, and it represents a coal market which, once gone, will never come back—not even indirectly through the increased demand for electricity. One way and another, the " indigenous fuel " argument had a bad year in 1954. Beyond these more conventional substitutes for coal lies the development of nuclear generation of electricity. It has been estimated that between the 40 MW output of the Calder Hall experimental atomic power station in Cumberland and the use of reactors using enriched nuclear fuel made possible from piles of which Dounreay in Caithness is a prototype, lies a gap of about 20 years. That is, 15 years beyond 1960, but all estimates on the rates of development in nuclear fission have proved over-conservative in the past, and the day when nuclear fission accounts for the gap of 20 million tons of coal may be nearer than 1975. Whenever it happens, this much can be said: that the development in nuclear generation will be proceeding at such a rate that much more will be involved for the coal industry and those who serve it than the provision of a marginal 20 million tons of coal.

In brief, the immediate prospects for those industries supplying the coal industry in this country are good. But the future, sometime after 1960, will begin to be affected by the competition which other forms of energy can offer to dear coal.

Exports of mining machinery did not have a good year in 1954. In contrast to the buoyant conditions in the home market, nearly all export markets returned poorer figures than in 1953, which, in turn, was lower than 1952. Exports of power-operated coal cutters were only slightly down, but power-operated winders were almost halved over the year in quantity and value. The actual figures are set out in Table I. As Table II shows, much the most severe fall was encountered in the South African market where trade was affected by the small investment in plant by the gold mining industry. In Australia too, however, sales were disappointing to judge from the returns given in the *Trade and Navigation Accounts*. Chairmen's addresses to shareholders have made reference to the slow recovery in this particular market and to the growing local competition in the South African market.

B.E.A.'s INVESTMENT PROGRAMME

Shortage of steel has been a serious handicap to the investment programme of the British Electricity Authority but it hopes to build up its annual installation of new capacity from the 1,400 MW of last year to about 2,000 MW by 1960. Approval was given last year for the Authority to spend £1,250 millions over the next six years, which will involve a 50 per cent. expansion in generating capacity and about a 46 per cent. increase in sales. It has been estimated that in the winter of 1959–60, B.E.A. will need about 25,000 MW of output capacity. To achieve this, B.E.A. will have to instal about 10,000 MW of new capacity, taking out about 1,200 MW of obsolete plant. Since the industry must plan about six years in advance (for it takes that amount of time from planning capacity to getting it on load) the major decisions for the B.E.A. between 1955 and 1960 relate entirely to policy for the 1960's—except for decisions on how fast to retire completely obsolete equipment. In consequence, the pattern of equipment requirements by the electricity industry for the rest of the 1950's is already established.

An outstanding feature of that programme is the trend towards generating sets of larger capacity. Programmes recently completed or nearing completion show a preponderance of " standard " 30 and 60 MW sets. By contrast, the 1959 programme of 1,880 MW allows for only 680 MW of capacity from units at or under 60 MW. The balance will come from 4 sets of 100 MW, 5 of 120 MW and 1 of 200 MW.

TABLE I. UNITED KINGDOM: EXPORTS OF MINING AND WELL-DRILLING MACHINERY OTHER THAN PORTABLE POWER TOOLS.

—	Quantity (1,000 cwt.)			Value (£1,000)		
	1952	1953	1954	1952	1953	1954
Power-operated coal cutters ..	20	25	24	623	804	795
Power-operated winders ..	81	67	36	1,081	883	527
Underground conveyors	113	103	65	945	983	626
Others	263	227	204	4,842	4,889	4,469
Total	477	422	329	7,491	7,559	6,417

TABLE II. UNITED KINGDOM: EXPORTS OF MINING AND WELL-DRILLING MACHINERY OTHER THAN PORTABLE POWER TOOLS, BY COUNTRIES OF DESTINATION.

—	Quantity (1,000 cwt.)			Value (£1,000)		
	1952	1953	1954	1952	1953	1954
Union of South Africa	92	62	29	1,296	988	488
Northern Rhodesia	15	24	21	171	328	311
India	34	28	28	546	529	481
Singapore	1	1	1	14	10	16
Federation of Malaya	41	8	14	338	73	127
Australia	67	64	45	704	740	689
Trinidad	9	11	16	186	226	258
Other Commonwealth countries and Irish Republic	75	78	81	1,220	1,340	1,495
Netherlands	10	13	6	156	247	145
Venezuela	28	26	17	675	799	595
Other foreign countries ..	105	107	71	2,185	2,279	1,812
Total	477	422	329	7,491	7,559	6,417

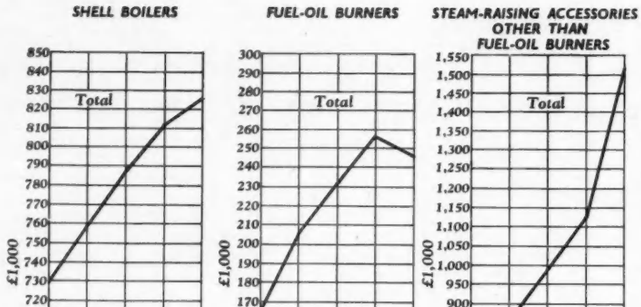


Fig. 3 U.K. deliveries of steam-raising plant (monthly averages, 1954 figures based on totals for 9 months). In the case of shell boilers and steam-raising accessories export figures were good. There are also good opportunities for replacement sales in this country.

This last set will break new ground in design in this country.

ECONOMIES OF LARGE SCALE OPERATION

While in theory, the economies of larger scale operations can be obtained from fewer sets of larger capacity, the issues involved are exceedingly complex. Technical difficulties arise in the combustion of certain British coals, as when bonded deposits form containing significant quantities of chlorides. These occur notably in the eastern areas of the East Midlands from which an increasing proportion of the B.E.A.'s coal will come. The view is held at present that the best way to handle this situation is to concentrate the chlorides on a few power stations with specially designed boilers. These may well be larger and more expensive per unit of steam than is usual. This solution, however, cuts across the economies expected to be obtained from new, large installations based on East Midlands coal and dependent upon boilers with high steam pressures and temperatures. It would seem therefore that the success of a policy of building large units to consume low-grade coals must depend on successfully attaining higher steam conditions which, in turn, call for increasing the rate of advance in piping techniques.

It cannot therefore be lightly assumed that the answer to dear coal is to consume lower grades in larger generating units. This may well be part of the answer, but not the whole of it. Here is an issue for generation policy in the 1960's and beyond, when nuclear generation is becoming increasingly significant. In the end it is expected that nuclear generation will dictate the siting of new plant to a large extent, but in between the present "coal age" and the eventual "nuclear age" there may be a time when oil firing has a part to play. The new station in Hampshire with dual firing has already been referred to, and if technical opinion at the B.E.A. moves further in that direction, the siting of large stations at river and estuary points where oil can be cheaply discharged may become more fashionable—at least for a time.

The B.E.A. is, however, very closely wedded to the trend in large coal-burning generating units near key coalfields for some time. Not only is the capital commitment in new power stations of this kind up to 1960 very heavy, but so also is the growing investment in the 275 kV Supergrid which is now being extended in accordance with an ambitious plan for completion by 1960. One of the main functions of the Supergrid is to distribute the power from the large new stations being built on the coalfields.

While prospects for heavy electrical plant and machinery in the home market have stayed buoyant, exports in 1954 were generally disappointing. As Fig. 2 shows, the result has been that an indifferent export performance has pulled down total deliveries. From Table III it is clear that on the whole the rather higher prices obtained in export markets for electrical machinery last year kept the value of exports only about 2 per cent. below that of 1953. Diesel-driven generators had a successful year in export markets, but transformer and switchgear exports were less satisfactory. It is very noticeable that while exports of electrical machinery to Europe and the United States have been buoyant in 1954, those to the Dominions and certain of the Colonies have been exceedingly disappointing, especially to South Africa and India. The outlook in some of these markets remains problematical, but any slack which develops owing to slow placing of orders from overseas could conceivably be taken up by the first orders for electrical equipment under the 15-year modernisation programme for the railways.

STEAM-RAISING PLANT

In the last complete financial year, B.E.A. installed 57 new boilers compared with 68 the year before. This probably reflects the time of installation, a factor which must affect the number of boilers installed in any one year as distinct from the annual trend. Nevertheless, the trend for future years is towards fewer and larger boilers. As Table IV shows, the export of water-tube boilers has gone down again in 1954 after a serious decline in 1953. As in the case of electrical machinery, there are definite signs of a lull in investment in generating plant and equipment abroad.

In the case of shell boilers and steam-raising accessories, however, the picture is quite different, as Fig. 3 shows. Exports were good in both cases while home deliveries were down last year in the case of shell boilers. The opportunity which exists for raising sales of boilers was shown in the steam and power usages survey undertaken by the Ministry of Fuel and Power in 1953 and published last year. The survey, which was limited to larger factories, found that of the 11,000 boilers included, over 6,000 were Lancashire boilers and two-thirds of these were over 30 years old. Even among the economic and water-tube boilers, one quarter were over 30 years old. The scope for modernisation, if adequately backed by sales persuasion, is obvious in both categories. These boilers, in many cases, must long since have had their depreciation charge written off, but the drive for greater fuel efficiency is gathering momentum and a year which sees the days of the steam locomotive numbered may also see a successful drive for more up-to-date boilers in British industry.

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SCHOLARSHIPS ABROAD

British Council Arrangements

Over 100 scholarships are being offered to British students for study abroad during the academic year 1955-56, by Austria, Belgium, Brazil, Denmark, Finland, France, Germany, Iceland, Italy, the Netherlands, Norway, Persia, Portugal, Spain, Sweden, Switzerland and Yugoslavia. The scholarships, most of which correspond to those offered by the British Council to students from these countries, are mainly for university graduates and undergraduates, but some are open to persons with non-academic professional qualifications.

The awards generally provide for free tuition and maintenance, and are tenable for periods varying from a few weeks to 12 months. Closing dates for the receipt of applications differ for each country, the earliest being March 7, 1955.

Further information and application forms, for which a stamped, addressed foolscap envelope should be sent, may be obtained from any British Council office in the United Kingdom, or from the Controller, Education Division, British Council, 65 Davies-street, London, W.1.

TABLE III. UNITED KINGDOM: EXPORT OF ELECTRICAL MACHINERY.

—	Quantity (1,000 cwt.)			Value (£1,000)		
	1952	1953	1954	1952	1953	1954
Generators complete:						
Driven by Diesel engines:						
not exceeding 200 kW ..	182	143	150	4,899	3,879	3,923
Exceeding 200 kW	117	72	154	2,579	1,778	4,140
Other generators	78	81	73	2,488	2,662	2,556
Generators without prime movers and parts	241	293	232	6,959	8,403	7,180
Total	618	589	609	16,925	16,722	17,799
Converting machinery	16	14	9	488	442	332
Transformers	607	674	559	10,479	12,520	10,654
Rectifiers for power-house use ..	21	20	14	755	798	634
Switchgear and switchboards ..	470	455	419	15,500	16,145	15,222
Steam turbines	113	151	210	3,844	5,577	7,073
Total	1,227	1,314	1,211	31,066	35,482	33,915

TABLE IV. UNITED KINGDOM: EXPORTS OF BOILERS AND BOILER-HOUSE PLANT.

—	Quantity (1,000 cwt.)			(Value £1,000)		
	1952	1953	1954	1952	1953	1954
Water-tube boilers	767	617	570	7,024	6,951	6,606
Vertical boilers	41	32	33	399	391	386
Other boilers	177	184	185	1,545	1,621	1,853
Economisers, feed-water heaters, and steam super-heaters ..	146	137	98	1,346	1,207	1,022
Other boiler-house plant	414	454	458	5,051	6,062	6,780
Total	1,545	1,424	1,344	15,365	16,232	16,647

THE PLANNING AND INSTALLATION OF A LABORATORY

PROVIDING A WIDE RANGE OF ENGINEERING SERVICES

"Engineering Services in a Laboratory," was the subject of a lecture given by Mr. J. C. Knight of the Ministry of Works, before the Institution of Heating and Ventilating Engineers in London, on January 19. After a brief survey of laboratory planning and the type of services required, Mr. Knight described in detail a recently completed laboratory. A summary of the main part of his lecture is given below.

The laboratory building to be described comprises two storeys with a third over the centre block and a half storey over the end "E" blocks. The centre-top storey houses light engineering equipment such as fans, motors and small refrigeration compressors, and the half storeys are used for distributing the various services throughout the end blocks. A separate boiler-house, an emergency electric generating station and a heavy machinery room are provided remote from the main building but with a connecting underground duct for the electrical and piped services. The whole of the ground floor of the centre block is devoted to general office accommodation, with the upper floor and both ground and first floors of the end blocks set aside for laboratory purposes.

The floor area was divided as follows: research laboratories and ancillary rooms, including workshops for metal workers, carpenters and glass-blowers, and washing-up and sterilising rooms occupied 50 per cent.; administration and general offices, 9 per cent.; storage of equipment and supplies, 7 per cent.; and engineering plant and services, 34 per cent.; the separate boiler-house and standby generating plant rooms raise the engineering portion of the floor area to 38 per cent., an unusually high figure which arose from the special nature of the work undertaken.

The project is almost entirely self-contained, having its own independent electricity generating station, steam-raising plant, water supply and storage, gas-generating plant and effluent disposal.

MAIN SUPPLIES AND PLANT

Water supply.—Water is carried by two 4-in. gravity mains which are fitted with valves so that either or both can supply the ring main. A static head of approximately 150 ft. is available from the reservoir, and the gravity mains, when both are in use, can deliver 6,000 gal. of water per hour with a friction loss of 25 ft. The ring main is connected directly to the water distribution system within the laboratory, where the pressure is sufficient for the operation of vacuum pumps and other scientific equipment.

All water is treated with chloramine, doses of which are automatically introduced into the delivery pipes.

Gas supply.—The peak gas requirements were estimated to be about 12·5 therms per hour with a further 17 therms per hour for other buildings nearby. The nearest towns' gas-producing plant, seven miles away, had insufficient capacity to meet this need. It was, therefore, decided to provide an independent gas-producing plant, and the method chosen was that of "cracking" gas oil, a process low in capital cost and simple in operation and maintenance. The gas produced has the exceptionally high calorific value of 1,350 B.Th.U. per cubic foot, allowing an appreciable reduction in size of the distribution and secondary mains as compared with those necessary for towns' gas.

A main 3,000-gal. oil storage tank is provided below ground level, from which the oil is pumped as required to a 150-gal overhead service tank feeding solid-fuel fired cast-iron retorts where it is cracked into gaseous form. In all, there are twelve producers, each capable of producing a minimum of 200 cub. ft. of gas per hour, but normally only six are in operation at any one time. In order to maintain a reasonable efficiency, the gas producers are not operated for more than about 24 hours without a rest period.

The gas consumption averaged 18,000 cub. ft. per month for the first 17 months of operation and is gradually increasing.

Steam-raising plant.—The maximum steam demand was estimated to be about 12,000 lb. per hour at 100 lb. per square inch gauge pressure. Three super-economic solid-fuel fired boilers were installed, each with an output of 6,000 lb. of steam per hour at 125 lb. per square inch gauge pressure. The third boiler is a standby and provides a margin of power for possible extensions. Firing is automatic by sprinkler stokers.

The boilers are connected into a steel flue at the back of the plant, which leads into a single brick chimney stack. Forced- and induced-draught fans are provided for each boiler and separate dust-collection equipment between each boiler and the horizontal steel flue.

Water-softening plant of the lime-soda type is provided inside the boiler-house, capable of treating 400 gal. of crude water per hour, which is sufficient to cope with future additional boilers. Two feed pumps, steam operated, are provided, each having a capacity of 1,800 gal. per hour.

CALORIFIERS

There are two calorifier chambers inside the main building, each containing a condensate receiving tank and pump. Heating calorifiers are fed with steam at mains pressure, but the hot-water storage calorifiers are supplied with steam at 25 lb. per square inch to provide for flash-steam recovery from the heating calorifiers.

Two mains are taken from each calorifier chamber to the third-storey plant space, one at high pressure and the other at 25 lb. per square inch. The former is used to feed air-heater batteries in the air-conditioning system and also autoclaves and sterilisers, and the low-pressure main supplies the laboratory bench outlets. Separate high-pressure connections also serve effluent sterilisation plants in the basement.

Refrigeration.—A major centralised refrigeration plant was required for the air-conditioning system, housed in the main generating-plant room isolated from the main building. Two twin-cylinder Freon compressors each capable of 60 tons of refrigeration and driven by 95-h.p. motors are used for this purpose.

Two horizontal shell and tube condensers are mounted one above the other and supplied with cooling water from a forced-draught water cooler, capable of handling 7,400 gallons water per hour and reducing this quantity in temperature to 75 deg. F. when operating in an atmosphere having a wet-bulb temperature of 65 deg. F. Two evaporators of the shell and tube type were provided for cooling brine, the brine being delivered into a storage cylinder having a capacity of approximately 4,000 gal. which is sufficient in the most adverse operating conditions to ensure satisfactory brine circulation for a period of 10 minutes without either compressor in operation. Automatic control is provided by thermostats at different levels in the brine storage cylinder.

Brine is circulated throughout the main building on a closed-circuit system, leaving the plant room with a temperature of 38 deg. F. and returning to the brine storage vessel at a temperature of 42 deg. F.

COMPRESSED-AIR APPLIANCES

Air compressors.—Compressed air, required throughout the building for driving air-motor operated centrifuges, operating automatic doors in corridors, and normal services outlets in the various laboratory rooms, is provided by two vertical-displacement two-stage air compressors, electrically driven by 77-h.p. motors automatically controlled. These compressors are situated in the plant room adjacent to the boiler-house. Each compressor is equipped with inter-stage and after-coolers and has a capacity of 350 cub. ft. per minute of free air at 100 lb. per square inch pressure.

There are no storage receivers in the plant room, but a number of relatively small receivers are housed in the plant space in the third storey. The laboratory outlets are served from secondary distributing pipework at a pressure of 25 lb. per square inch, but some high-pressure outlets (80 lb. per square inch) were also required. Compressed-air services were required in the cold rooms. The branch mains serving these areas are fitted with air dryers comprising duplicate silica-gel canisters, one being regenerated while the other is in use.

GENERAL SERVICES THROUGHOUT THE BUILDING

The hollow walls dividing the corridor from the laboratory rooms are built between brick columns spaced at approximately 4-ft. intervals. The hollow spaces serve for the installation of the various piped services, cables and air ducts. This arrangement gives flexibility for planning the engineering installations so that any service can readily be connected up to suit any later revised layout of rooms. Two trenches are provided in the ground floor, one on each side of the corridor, into which the vertical voids also connect.

Heating.—The necessity to avoid all exposed surfaces on which dust could collect led to the adoption of the low-temperature embedded-panel system of heating. Half-inch bore copper tube heating panels were placed in the ceiling, any upward losses contributing to the warming of the spaces above. The third-storey plant room had a steel-deck roof for lightness, and the upward transmission of heat from the ceiling below, coupled with the normal heat emission from the plant, was considered adequate.

The system was designed to operate at a flow temperature of 105 deg. F. with a return at 95 deg. F. This low temperature difference between flow and return was chosen to reduce, as far as possible, any stresses which might arise in the plaster ceiling due to temperature variations over the face of the panels. The calculated total heat load was approximately 5 million B.Th.U. per hour. The system has, in fact, been operated with the flow held at a steady 90 deg. F., and the variations in heat requirements due either to changes in the outside conditions or to the quantities of heat generated within the building are dealt with by the automatic controls of the air-conditioning plant.

PROBLEM OF OVERHEATING

When the building was completed and in occupation, it was found that the greatest problem was to reduce the amount of heat emitted by the system and the various pipework installations. Surface temperatures of various parts of the structure ranged between 80 deg. F. and 85 deg. F. Particular difficulty arose in the entrance halls and vestibules, which, although heated by ceiling panels, had no outside walls. The heating panels in these areas were eventually almost entirely closed down without having much effect on air temperature but with a noticeable effect on comfort.

Hot- and cold-water services.—Steam at a pressure of 25 lb. per square inch gauge serves storage-type calorifiers for domestic hot-water supply, having a total capacity of approximately 1,200 gal., the heater batteries being capable of heating the full storage quantity to 155 deg. F. in 2 hours. Circulation of hot water is maintained by electrically driven pumps operating against a head of approximately 4 ft.

The cold-water mains, besides supplying the

underground ring-main system, also serve the break tanks for the domestic hot-water service installations and the boiler-feed apparatus. The laboratory fittings are single-outlet and triple-outlet taps, arranged over small drip sinks, and also used for operating local vacuum pumps. These pumps do not operate satisfactorily with water pressures below 30 lb. per square inch and this dictated the general design of the entire cold-water service installation. This particular feature also required a system of pressurising the water supply for one area of the building in which special precautions had to be taken to prevent any possibility of contamination of the cold water by back-syphon effect.

In order to prevent freezing of the water in the pipes in the cold rooms, the system had to be self-draining. Separate legs fitted with valves were taken to the taps, the legs running horizontally at high level so that the tap was at the lowest point of the branch. Outside the cold room, at the point of entry of the service pipe through the partition wall, an isolating valve was also fitted. Thus, when an operator has finished work inside the cold room the tap must be left open and the isolating valve outside closed. The drain gulley is connected to a trap outside the room and a heavy cork plug provided to seal the gulley when not in use.

Air conditioning.—The air conditioning requirements necessitated sealed windows and a positive air input and extraction system. Moreover, air should be introduced at low level and extracted at the ceiling. Following the general principle of unit planning, it was decided to provide air inlets at 8-ft. intervals with air-extraction points diagonally opposite at the same spacing. The rate of air extraction was the same as that of discharge from the rooms to maintain balanced pressure conditions, and input grilles only were provided in the corridors to comply with requirements concerning excess air pressure. Air locks were provided at strategic points in the corridors sealing off staircase wells to prevent natural convection currents from upsetting the pressure/volume relationship of the various floors.

Double windows were chosen with the space between the two sheets of glass approximately 13½ in. in width. Into this space was fitted a Venetian-type blind with slats carefully curved and highly polished to reflect solar radiation. It was estimated that the transfer of solar radiation into the room would add approximately 26 per cent. to that which would be transmitted through clear, unshaded glass.

HEATING TO DEMAND

Preliminary calculations showed that the number of air changes generally required to deal with heat emitted from occupants and from the bunsen burners and other appliances within the building would be of the order of four per hour. This rate of air change was considered to be the maximum with which noticeable air movement could be avoided.

Investigations into the heat gains from all sources during summer established that cooling was necessary for much of that season. The outside air temperature selected as a basis was 75 deg. F., although it was known that on some 20 days a year the outside air would probably exceed 75 deg. F.

Humidity control was not required, but it was apparent that the air would at some periods have to be cooled below the dew point. It was decided that the plant should be capable of handling a dew point of 60 deg. F. associated with a dry-bulb temperature of 75 deg. F. and maximum solar radiation.

Table I shows how the theoretical demand for cooling varies according to the time of the day, or more correctly, to the position of the sun.

TABLE I.—*Cooling Load during the Day.*

	8 a.m.	10 a.m.	Noon	2 p.m.	4 p.m.	6 p.m.
Tons of Refrigeration ..	110	120	110	120	105	90

The theoretical demand for cooling at noon is less than that at 10 a.m. and 2 p.m. because a lower heat transmission through the glass of the southern aspect occurs at times of maximum solar radiation than that on either east or western aspects, due to the different position of the sun.

The total connected refrigeration load for the building, if separate refrigeration plants had to be provided for the maximum requirements of each of the zones, would have been about 160 tons. The actual refrigeration capacity required, taking the diversity factor for peak loads into accoint, is 120 tons. This indicates the advantages of a centralised refrigeration plant, even though the air-conditioning systems are separated for each of the various zones or sections of the building.

In all, some 14 separate plants were required for zoning purposes, but additional plants were installed to deal with separate suites of rooms where special processes were undertaken, requiring air-change rates varying from 1 to 10 per hour.

Each plant was provided with a brine cooling battery and a heater battery separated by a bank of eliminator plates. Precise control over humidity was not required and, therefore, air washers were not installed. In any event they would have been very undesirable pieces of equipment since they might be the means of introducing harmful bacteria or spores into the air stream. No recirculation was permissible because of the nature of the work undertaken.

COMPASS POINT ZONING FOR AIR COOLING

The lowest entering-air temperatures to the four zones with the cooling load at a maximum were calculated to be: north, 56 deg. F.; south, 49 deg. F.; east, 44 deg. F.; and west, 44 deg. F. Although these inlet temperatures seem extraordinarily low for rooms having an air temperature of 70 deg. F., and in spite of the fact that the air is introduced at low level, no noticeable discomfort is experienced in practice, perhaps because the inlets are located on the corridor walls, 14 ft. away from the research workers, at the benches below the windows. Also the type of air grille used is such as to produce a high entrainment of air and project a fan-shaped jet.

The numerous fume cupboards presented a particular problem in that the intermittent use of separate fans would upset the air-pressure balances. Accordingly, the air-extraction ducts from the fume cupboards were connected into the branch extract duct serving the particular room. At the point of junction motorised bifurcating dampers are provided, with a switch on the face of the fume cupboard, so that when the cupboard is in operation the extraction point in the ceiling is closed. In such cases the fume-cupboard requirements dictated the actual rate of air supply.

The total amount of air handled by the various input systems was 55,000 cub. ft. per minute. The air volume per ton of refrigeration is, therefore, 460 cub. ft. per minute. The total refrigeration provided corresponds to 0·15 ton per 1,000 cub. ft. of air-conditioned space, or 1·67 tons per 1,000 square feet of floor area.

Maximum economy in running costs is obtained by shutting down the air-input fans at the end of each working day and starting them up again two or three hours before work commences in the morning, depending on weather conditions. The extract fans are kept in operation at reduced output during the night and at week-ends, because it was found that with fans of both systems closed down there was a tendency for reversed circulation.

DUST EXTRACTION

Air filtration.—99·9 per cent. of all dust particles of size 0·5 micron or larger had to be abstracted from the incoming air. A dry fabric material had already been developed to meet this requirement. The material—resin-impregnated wool—was received from the manufacturer with a thickness of approximately 3 in., but had to be compressed to ½ in. thick to meet the filtration efficiency requirements. The pressure required to compress the material was calculated to be about 2 lb. per square inch.

To maintain a constant air volume irrespective of the condition of the filters, some kind of variable-speed fan was obviously required, and it was decided to install variable-speed direct-current motors. "Roughing" filters were also provided at the air intakes.

An even more severe specification was laid down for the filters in the plants serving some of the experimental areas. Here, a mixture of wool and asbestos fibres was used. All the filtration plants were designed to be under a negative pressure so that any possible air leaks through the duct connections would be inwards and would have to pass through the filtering material before entering the discharge side.

A total of 2,034 canister filters were installed, 1,290 being of the resin/wool type. This is probably the first large-scale industrial application of these types of filtering media and of such a stringent specification.

Operational experience shows that the filters have a life of nine months if roughing filters are not used. With the roughing filters in use the life is extended to 21 months. To increase the life still further the practice of vacuum cleaning the inserts has been employed. Where roughing filters were not provided the life has been increased from nine to 27 months and in the other cases it is estimated that the filters will last about five years.

Hot rooms.—A number of hot rooms were required in the various laboratory areas, with automatic control of temperature to within plus or minus half a degree Centigrade, with a minimum of air movement and as uniform a temperature distribution as possible. It was decided to employ radiant electric heating panels fitted to cover almost the whole ceiling area, and in some cases at high level on the walls. The latter were specially insulated.

A difficulty arose in practice from the effect of radiation from the ceiling on to trolleys of bottled chemicals. This was largely overcome by providing polished aluminium shields over the trolleys to reflect radiation back to the surroundings.

COOLING CONTROL

Cold rooms.—A number of cold rooms were also required, some of which were to be maintained at a predetermined temperature within ± 1 deg. C. in the range − 5 deg. C. to + 5 deg. C. and others within the range − 30 deg. C. to + 5 deg. C. All of these cold rooms were insulated with 8-in. thick cork finished with a ½-in. thickness of polar-white cement and painted Cith anti-corrosive paint. A separate refrigeration compressor with its own air-cooled condenser was provided for each cold room. The cooling surfaces almost completely covered the wall areas from floor to ceiling. Since still-air conditions were also required in these cold rooms, the cold air-blast system could not be adopted, and no coils were provided on the ceilings owing to the possibility of condensation dropping from them on to equipment within the rooms. All cold rooms were entered through an air lock, in which were provided temperature indication and control instruments.

Distilled water.—Distilled water is supplied from six steam-operated stills mounted in pairs in the third storey immediately above the laboratories concerned. Distribution is by aluminium piping to draw-off points in the various rooms. The stills are of tinned-copper construction, with a capacity of 8 gal. per hour each when supplied with steam at 45 lb. per square inch. Three welded aluminium cylindrical storage vessels, each having a capacity of approximately 85 gal., were provided adjacent to the stills. The copper-ball floats originally provided on the storage vessels gave rise to traces of copper sulphate in the distilled water and so were eventually replaced by specially made glass floats. The entire installation was automatically controlled by float switches on the storage vessels and motorised valves on the incoming raw-water and steam supplies.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Industrial Management. *Public Relations Officer, The United Steel Companies, Limited, 17 Westbourne-road, Sheffield, 10.* (Free on application.) This book contains a series of lectures given at Cambridge University, for the Faculty Board of Engineering, by senior members of the staff of the United Steel Companies, Limited. The subjects covered include the role of the directing authority in a large company, production management, administrative controls, the duties and problems of the chief engineer, and organisation and application of scientific research in industry.

Basic Television: Principles and Servicing. By BERNARD GROB. Second edition. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York, 36, N.Y., U.S.A.* (6 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (64*s.*)

Most of the material in the first edition has been rewritten and new illustrations added to bring the work up to date, and to provide more practical information on servicing. New features include a thorough explanation of colour television, a fuller explanation of the radio detector circuit, and a separate chapter on automatic gain control.

The Chemical Industry in Europe. *Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris, 16e.* (9*s.*)

This report has been prepared by the O.E.E.C. Chemical Products Committee to provide a survey of the economic situation in the various industrial sectors in member countries. The first part briefly surveys the situation in the chemical industry of O.E.E.C. countries as a whole, setting out the main economic aspects; the second part shows the situation of the chemical industry in the individual countries, and describes in greater detail the development of production and trade in different sectors of the industry.

Welding for Engineers. By HARRY UDIN, EDWARD R. FUNK and JOHN WULFF. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (7.50 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (60*s.*)

This book is based on a set of notes used as text material in a course at the Massachusetts Institute of Technology. Each unit process is presented as soon as possible after its basic principles have been developed, so that the principle of metallic adhesion, for example, is followed by the process of cold welding. As understanding progresses, more complicated processes are used for illustration. The emphasis is on principles rather than practice, and the authors state that one of the main purposes of the book is to stimulate "the desire to do advanced research in the welding field."

Introduction to Atomic and Nuclear Physics. By HENRY SEMAT. Third edition. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (50*s.*)

As in earlier editions, this book is intended for students who have had a one-year physics course, and a course in calculus. The original title, "Introduction to Atomic Physics," has been changed since nuclear physics has come to be considered as a separate branch of physics. Thus, the major change in this edition is in the section on nuclear physics. The chapter on natural radioactivity has been brought up to date. Other chapters describe experiments on the disintegration of nuclei, the theory of nuclear processes, the physical aspects of fission, and the newer particles—the mesons and V-particles.

Highway Engineering. By LAURENCE I. HEWES and CLARKSON H. OGLESBY. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (8 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (64*s.*)

This book is designed primarily as a text for junior and senior college courses in highway engineering, but also offers a starting point for advanced courses and individual study, and provides a summary of important developments for practising highway engineers. Greater stress is placed on engineering design and the principles that underlie it than on actual construction practices. Chapters on soils, bases and pavements give particular attention to design techniques and to the results of recent research. Other subjects covered include highway economy and finance, drainage, rights of way, and traffic engineering.

FRICTION AND HEAT TRANSFER IN COOLING TOWERS

The disposal of the heat withdrawn from the steam generators is a factor of great importance in the siting of an electricity generating station. When, for over-riding reasons such as the proximity of fuel supplies or the necessity to serve a large industrial area, the station lacks an abundant natural supply of cold water, the alternative of cooling condensing water by cooling towers presents problems of design and operation that significantly affect the economy of generation. Theoretical aspects of some of these problems and practical methods of solving them are the subjects of two papers* presented on January 5 to the Institution of Electrical Engineers by members of the firm of Kennedy and Donkin, 12 Caxton-street, London, S.W.1.

The first paper is based on the experimental fact that the rate of heat transfer from a fluid to the solid boundaries between which it is flowing is augmented by increase of the fluid friction due to the boundaries. From available data on the friction/heat transfer characteristics of different systems in use as packings inside cooling towers, Mr. Margen has prepared a chart from which the optimum friction factor, the economic packing surface per unit of ground area, and the corresponding cooling tower performance coefficient can be read off for values of two design constants, namely the air-flow resistance of the tower shell, and the comparative cost of extending the ground area and the packing surface. Typical values of these constants for different conditions lead to the conclusion that the optimum friction factor varies over a five-fold range, being lowest for small mechanical-draught towers situated on expensive land, and highest for large natural draught towers. The economic duty conditions of mechanical- and natural-draught cooling towers in British types of climate are further explored in the second paper, attention being given to combined tower and river cooling schemes.

Whilst the quantitative formulae and conclusions of these papers relate specifically to power station cooling towers, they obviously apply, with no more than minor modifications, to similar towers used for industrial processing. The basic principle of determining an optimum design by consideration of experimental values of the friction/heat-transfer relation for alternative forms and arrangements of fluid flow boundaries, exemplified by the first paper, is of course far more general and calls for correspondingly major adaptation for other applications. Since, however, the inter-relation between fluid friction and heat transfer is universally influential throughout a great and expanding range of industrial heat-exchange apparatus, mathematical and graphical methods on the lines of those developed by Mr. Margen may prove superior to some now being used.

* Paper S1705: "The Application of Friction/Heat-Transfer Correlations to Cooling Tower Design", by P. H. Margen.

Paper S1706: "The Economic Selection of Cooling Towers for Generating Stations", by G. F. Kennedy & P. H. Margen.

STRESSES IN PLATES WITH CRACKS AND NOTCHES

A THEORETICAL AND EXPERIMENTAL INVESTIGATION

By M. Rothman and D. S. Ross†*

The problem of an infinite plate containing a crack has been investigated by various authors in the past, all of whom considered the crack to be the limiting case of an elliptical hole, the minor axis of which tended to zero. Using the methods of complex variable, however, an alternative method of solution can be obtained which lends itself to the solution of the problem for several forms of boundary loading not previously discussed.

This article is divided into two sections. The first part gives the theoretical solution of an infinite plate containing a crack for various forms of loading, and by comparison with one of the practical results which was obtained for a finite plate shows that, subject to the crack being no more than one-sixth the width of the plate, the latter may be considered for all theoretical purposes as infinite. A solution is also given for a semi-infinite plate with a notched boundary, the notch taking the form of a cusp. This, though not the same as the boundaries considered in the second part of the paper, gives an interesting approximation to the case of a crack and in certain circumstances is a fairly accurate representation.

The second part of the article is an account of a photo-elastic investigation of a finite plate containing a crack, and also that of a plate containing a notched boundary, the notch successively taking the form of a semi-circle, a semi-ellipse, and a crack.

This last problem—of a crack—seems to have been incapable of theoretical solution so far, and the method of approach (that is, form of notches considered) was designed to be of possible future use in checking any theoretical solution that might be forthcoming as well as giving an experimental solution of the problem.

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1—THEORETICAL INVESTIGATION

Definitions and Formulae.—The various quantities used are defined as follows.—

$\widehat{pq}$ = the stress intensity across a face perpendicular to the direction of p, and resolved in the direction of q, for a material in the state of plane strain;

u, v = the displacements at the point (x, y) in the direction of Ox, Oy, rectangular axes through the centre of the crack;

μ = Lamé's constant, the rigidity;

η = Poisson's ratio for plane strain;

E = Young's Modulus;

τ = the maximum shearing stress at any point;

κ = the bulk modulus $(= 3-4\eta)$; and

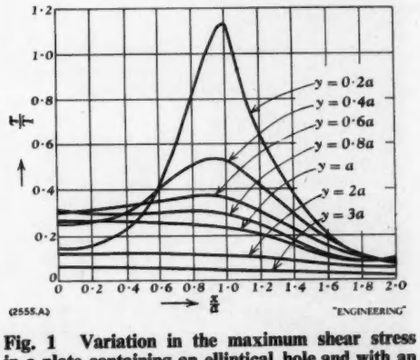


Fig. 1 Variation in the maximum shear stress in a plate containing an elliptical hole and with an all-round tension T applied at infinity. The minor axis of the hole has been made so short as to make the hole virtually a crack.

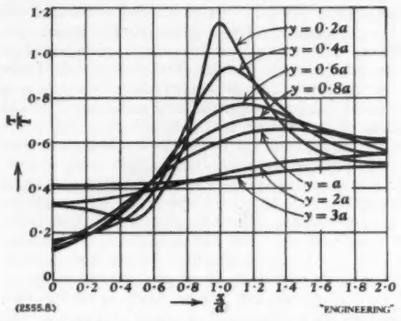


Fig. 2 Variation in the maximum shear stress in a plate containing an elliptical hole of zero minor axis and subjected to a simple tension T applied at infinity and parallel to the minor axis.

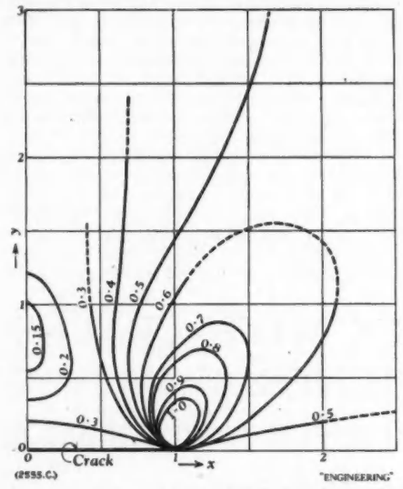


Fig. 3 Isochromatics deduced from Fig. 2 by determining lines of constant T. These theoretical patterns should be compared with those obtained experimentally and shown in Fig. 10.

$z = x + iy$, $D = u + iv$, $\Theta = \hat{xx} + \hat{yy}$, $\Phi = \hat{xx} - \hat{yy} + 2i\,\hat{xy}$.

In the absence of body forces the following relations hold[1]:

$$8\mu D = \kappa\,\Omega(z) - z\,\overline{\Omega}'(\bar{z}) - \overline{\omega}'(\bar{z}) \quad (1\cdot1)$$

$$2\Theta = \Omega'(z) + \overline{\Omega}'(\bar{z}) \quad (1\cdot2)$$

$$-2\Phi = z\,\overline{\Omega}''(\bar{z}) + \overline{\omega}''(\bar{z}) \quad (1\cdot3)$$

where $\Omega(z)$ and $\omega(z)$ are two complex potential functions.

2—UNIFORM PRESSURE AT CRACK BOUNDARY

Considering an ellipse to be given by the transformation in the z-plane of the unit circle in a complex σ-plane, where $z = c(\sigma + \lambda\sigma^{-1})$, c and λ being constants, the normal and shearing stresses $\hat{nn}$ and $\hat{sn}$ round the boundary of an elliptical hole must satisfy the equation:

$$4(\hat{nn} + i\,\hat{sn})\frac{dz}{ds} = \frac{d}{ds}[\Omega_0(z) + z\,\overline{\Omega}_0'(\bar{z}) + \overline{\omega}_0'(\bar{z})]. \quad (2\cdot1)$$

For uniform pressure round the boundary, $\hat{nn} = -p$, $\hat{sn} = 0$, and equation (2·1) can readily be shown to reduce to.—

$$z'(\sigma)\,\overline{\Omega}(\sigma^{-1}) + \bar{z}(\sigma^{-1})\,\Omega'(\sigma) + \omega'(\sigma) + 4p\,\bar{z}(\sigma^{-1})\,z'(\sigma) = 0. \quad (2\cdot2)$$

Now tentatively assuming the potentials to be of the form $\Omega(\sigma) = A\,c\,\sigma^{-1}$ and

$$\omega(\sigma) = B\,c^2\sigma^{-2} + C\,c^2\log\sigma,$$

it is found on substituting in equation (2·2) that $A = -4\lambda p$; $B = 0$; and $C = -4p(1+\lambda^2)$, so that:

$$\Omega(\sigma) = -4\lambda\,c\,p\,\sigma^{-1} = -2(a-b)\,p\,\sigma^{-1} \quad (2\cdot3)$$

$$\omega(\sigma) = -4c^2(1+\lambda^2)\,p\log\sigma = -2(a^2+b^2)\,p\log\sigma \quad (2\cdot4)$$

where a, b are the semi-axes of the ellipse.

As the minor axis tends to zero, the hole becomes a crack of length $2a$, and the potentials (2·3) and (2·4) become

$$\Omega(\sigma) = \frac{-2ap}{\sigma},\quad \omega(\sigma) = -2a^2p\log\sigma. \quad (2\cdot5)$$

Also as b tends to zero, λ tends to unity, so that $a = 2c$, and the relation between z and σ becomes

$$z = c\left(\sigma + \frac{1}{\sigma}\right). \quad (2\cdot6)$$

Differentiation of equations (2·5) gives

$$\Omega'(z) = \frac{2ap}{c(\sigma^2-1)};\quad \Omega''(z) = \frac{-4ap\sigma^3}{c^2(\sigma^2-1)^3};$$

$$\omega'(z) = \frac{-2a^2p\sigma}{c(\sigma^2-1)};\quad \omega''(z) = \frac{2a^2p\sigma^2(\sigma^2+1)}{c^2(\sigma^2-1)^3}.$$

Substituting in equation (1·3) then gives

$$\Phi = \frac{4p}{c}\left\{z\,\frac{\bar{\sigma}^3}{(\bar{\sigma}^2-1)^3} - \bar{z}\,\frac{\sigma^3}{(\sigma^2-1)^3}\right\}. \quad (2\cdot7)$$

Now taking polar co-ordinates such that

$$z = re^{i\theta} = c\left(\sigma + \frac{1}{\sigma}\right) = \frac{c(\sigma^2+1)}{\sigma},$$

$$z - 2c = r_1 e^{i\theta_1} = c\left(\sigma + \frac{1}{\sigma} - 2\right) = \frac{c(\sigma-1)^2}{\sigma},$$

and

$$z + 2c = r_2 e^{i\theta_2} = c\left(\sigma + \frac{1}{\sigma} + 2\right) = \frac{c(\sigma+1)^2}{\sigma},$$

then,

$$\frac{z}{c} = \frac{re^{i\theta}}{c} \quad\text{and}\quad \frac{\bar{\sigma}^3}{(\bar{\sigma}^2-1)^3} = \left[\frac{c^3e^{i(\theta_1+\theta_2)}}{r_1r_2}\right]^{\frac{3}{2}},$$

and (2·7) becomes

$$\Phi = \frac{4pr}{c}(e^{i\theta} - e^{-i\theta})\left[\frac{c^3e^{i(\theta_1+\theta_2)}}{r_1r_2}\right]^{\frac{3}{2}},$$

so that, separating real and imaginary parts,

$$\hat{xx} - \hat{yy} = \frac{-pra^2}{(r_1r_2)^{\frac{3}{2}}}\,2\sin\theta\sin\tfrac{3}{2}(\theta_1+\theta_2),$$

and $2\hat{xy} = \dfrac{pra^2}{(r_1r_2)^{\frac{3}{2}}}\,2\sin\theta\cos\tfrac{3}{2}(\theta_1+\theta_2)$.

The maximum shearing stress at any point is then given by

$$4\tau^2 = (\hat{xx} - \hat{yy})^2 + (2\hat{xy})^2$$

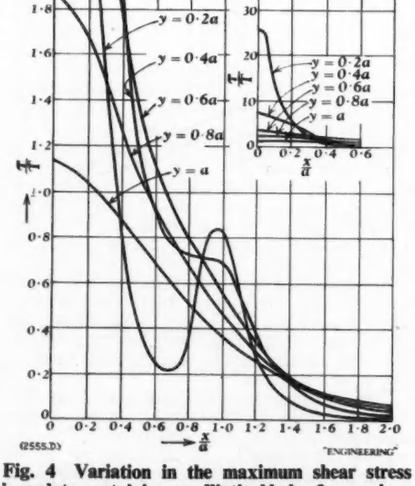


Fig. 4 Variation in the maximum shear stress in a plate containing an elliptical hole of zero minor axis and with diametrically opposite forces applied at the ends of the minor axis. This state is comparable with a wedge being driven into the hole or crack.

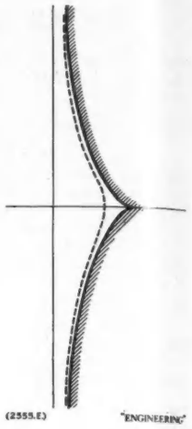


Fig. 5 The theoretical treatment of a plate with an edge crack had proved intractable, but representation of the cracked edge by the cubic curve shown here will permit variations in the shear stresses to be deduced.

or

$$\tau = \frac{pra^2}{(r_1r_2)^{\frac{3}{2}}}. \quad (2\cdot8)$$

Also, substituting the values of the complex potentials in equation (1·1) the displacement at any point is found to be given by

$$8\mu D = \frac{-2ap(3-4\eta)}{\sigma} - \frac{az}{c} - \frac{ap}{c(\bar{\sigma}^2-1)} + \frac{2a^2p}{c}\,\frac{\bar{\sigma}}{\bar{\sigma}^2-1},$$

so that if $\sigma = i$, the displacement at the end of the "minor axis" is given by $8\mu D = i\,8ap(1-\eta)$, and so $u = 0$ and

$$v = \frac{ap(1-\eta)}{\mu} = \frac{2ap(1-\eta^2)}{E}. \quad (2\cdot9)$$

The quantity v as given by equation (2·9) denotes the length of the semi-minor axis of the crack, that is, half its maximum width, and the relationships (2·8) and (2·9) are those otherwise obtained by Sneddon.[2]

The lines of constant maximum shearing stress can be obtained by writing $\tau = \alpha p$ in equation (2·8) which then becomes:

$$\alpha^2[(x-a)^2+y^2]^{\frac{3}{2}}[(x+a)^2+y^2]^{\frac{3}{2}} = a^4y^2, \quad (2\cdot10)$$

where α is a parameter, and different values of α give the photo-elastic isochromatic lines.

{It may be noted that expression (2·10) is given incorrectly by Sneddon as

$$\alpha[(x-a)^2+y^2]^{\frac{1}{2}}[(x+a)^2+y^2]^{\frac{1}{2}} = a^2y^4.\}$$

3—OTHER FORMS OF PLATE LOADING

The state of stress in a plate containing a crack which is subjected to some other loading can be similarly investigated provided the complex potentials for the appropriate problem are known.

Three such cases are those of (*a*) the plate under all-round tension at infinity, (*b*) the plate under simple tension at infinity, and (*c*) diametrically opposite forces at the ends of the "minor axis" of the crack. The results of these problems are given below.

(*a*) *All-round Tension at Infinity.*—The complex potentials for an elliptical hole subject to an all-round tension T at infinity, are found to be.—

$$\left.\begin{aligned}\Omega(\sigma) &= 2\,T\,c\left(\sigma - \frac{\lambda}{\sigma}\right)\\ \omega(\sigma) &= -4\,T\,c^2(1+\lambda^2)\log\sigma\end{aligned}\right\}, \quad (3\cdot1)$$

so that, putting $\lambda = 1$, the potentials appropriate to the case of a crack become:

$$\left.\begin{aligned}\Omega(\sigma) &= 2\,T\,c\left(\sigma - \frac{1}{\sigma}\right)\\ \omega(\sigma) &= -8\,T\,c^2\log\sigma\end{aligned}\right\}. \quad (3\cdot2)$$

Substituting these expressions in equation (1·2), the previous method gives

$$\hat{xx} - \hat{yy} = -\frac{Tra^2}{2(r_1r_2)^{\frac{3}{2}}}[\cos\theta\cos\tfrac{3}{2}(\theta_1+\theta_2) + 3\sin\theta\sin\tfrac{3}{2}(\theta_1+\theta_2)],$$

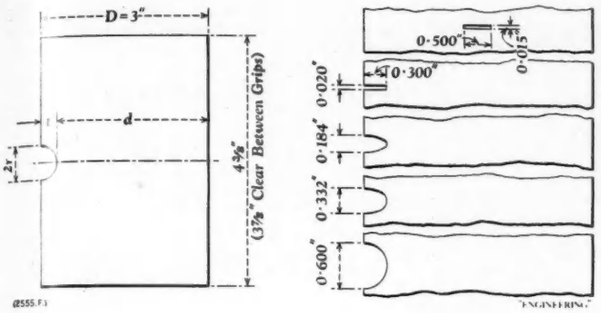


Fig. 6 Forms of five specimens of Columbia resin sheet with different edge or body discontinuities used in the photo-elastic experiments. The experimental results are compared with those deduced for theoretically infinite plates.

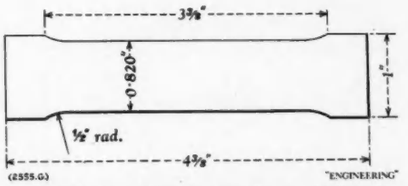


Fig. 7 Simple calibration specimen. Calibration was determined by loading the strip in tension and noting the loads for each change of integral fringe order.

and

$$2\hat{xy} = -\frac{T\,r\,a^2}{2\,(r_1\,r_2)^{\frac{3}{2}}}\,[\cos\theta \sin\tfrac{3}{2}(\theta_1+\theta_2) - 3\sin\theta\cos\tfrac{3}{2}(\theta_1+\theta_2)],$$

with a maximum shearing stress

$$\tau = \frac{T\,r\,a^2}{4\,(r_1\,r_2)^{\frac{3}{2}}}\,[1+8\sin^2\theta]^{\frac{1}{2}}. \quad . \quad (3\cdot3)$$

The variation of τ with x and y was computed from this formula and the results are shown in Fig. 1 on page 175.

(*b*) *Simple Tension at Infinity.*—If the plate containing an elliptical hole is under simple tension T at infinity, in a direction β to the axis of the ellipse, then[5]:

$$\left.\begin{aligned}\Omega(\sigma) &= T\,c\left[\sigma + \left(\frac{2\,e^{2i\beta}-\lambda}{\sigma}\right)\right]\\ \omega(\sigma) &= -\,T\,c^2\,[e^{-2i\beta}\,\sigma^2 + e^{2i\beta}\,\sigma^{-2} + 2\,(1-2\,\lambda\cos 2\,\beta+\lambda^2)\log\sigma]\end{aligned}\right\}, \quad (3\cdot4)$$

so that for a crack in a plate in which the tension is parallel to its "minor axis" $\beta = \frac{1}{2}\pi$ and $\lambda = 1$, and

$$\left.\begin{aligned}\Omega(\sigma) &= T\,c\left(\sigma - \frac{3}{\sigma}\right)\\ \omega(\sigma) &= T\,c^2\left(\sigma^2 + \frac{1}{\sigma^2} - 8\log\sigma\right)\end{aligned}\right\}. \quad (3\cdot5)$$

Substitution in the previous expressions leads to the results

$$\hat{xx} - \hat{yy} = \frac{-\,T\,r\,a^2}{(r_1\,r_2)^{\frac{3}{2}}}\,2\sin\theta\sin\tfrac{3}{2}(\theta_1+\theta_2) - T,$$

and

$$2\hat{xy} = \frac{T\,r\,a^2}{(r_1\,r_2)^{\frac{3}{2}}}\,2\sin\theta\cos\tfrac{3}{2}(\theta_1+\theta_2),$$

the maximum shearing stress τ now being given by

$$\tau^2 = \left\{\left[\frac{T\,r\,a^2}{(r_1\,r_2)^{\frac{3}{2}}}\sin\theta + T\sin\tfrac{3}{2}(\theta_1+\theta_2)\right]\times\left[\frac{T\,r\,a^2}{(r_1\,r_2)^{\frac{3}{2}}}\sin\theta\right] + \frac{T^2}{4}\right\}. \quad (3\cdot6)$$

The corresponding curves of the variation of τ with x and y are shown in Fig. 2 on page 176.

Since isochromatics are lines along which τ is constant, these can be readily obtained from a graph of τ as was done in this case, the results being shown in Fig. 3.

These isochromatics may be compared with those of Fig. 10 which were obtained experimentally, and for which a finite plate with a length about six times the length of the crack was used. It will then be seen that the theoretical solution for the infinite plate gives perfect agreement with the practical solution for the finite plate, provided that the length of the crack is not more than one-sixth of the width of the plate, which is not normally likely to be the case.

In both cases (*a*) and (*b*), the semi-minor axis of the crack can be shown to be equal to $\frac{2\,T\,a\,(1-\eta^2)}{E}$, where T has its respective meaning. Using the condition that the crack may extend, as given by Griffith[2],

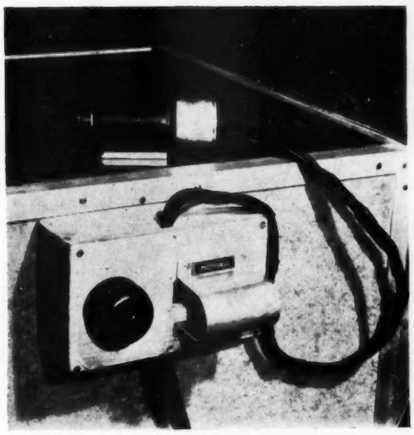
$$\frac{\partial}{\partial a}(W - U) = 0, \quad . \quad (3\cdot7)$$

it is readily shown that if

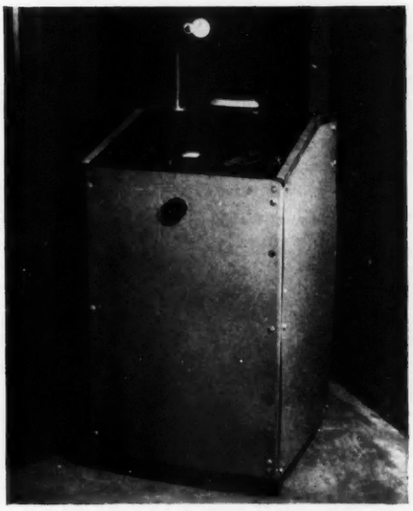
$$a = \frac{2\,E\,t}{\pi\,T^2\,(1-\eta^2)}$$

the crack will extend; t is the surface tension of the material.

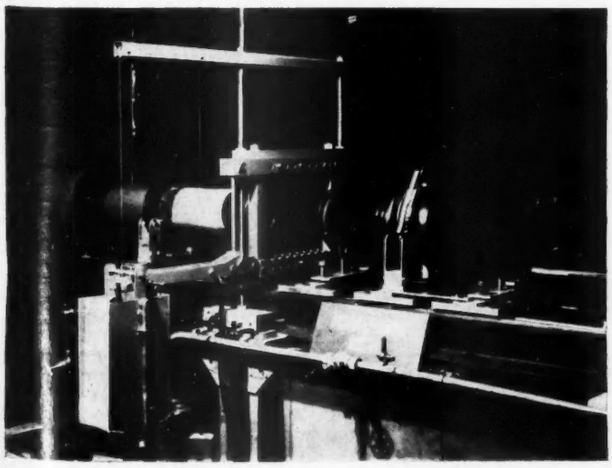
Fig. 8 Photoelastic apparatus used in experimental investigation.



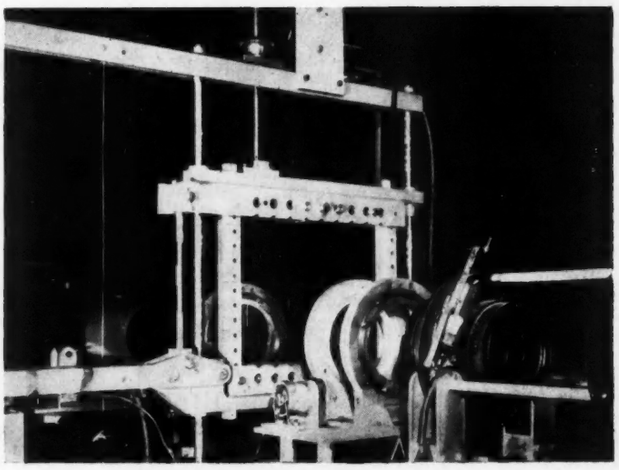
(*a*) Cabinet with viewing screen and the photoelectric multiplier used for scanning the fringes.



(*b*) Cabinet with power pack, transformers, etc., for controlling the straining frame and polaroids.



(*c*) Layout showing mounting of the elements on the polariscope.



(*d*) Straining frame and optical system.

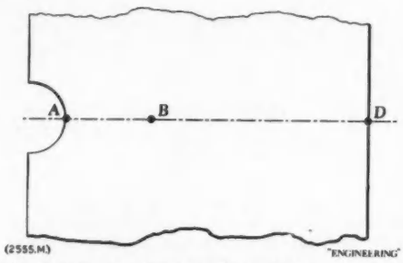


Fig. 9 The distribution of the difference of the principal stresses was determined by the "fringe travel method" described.

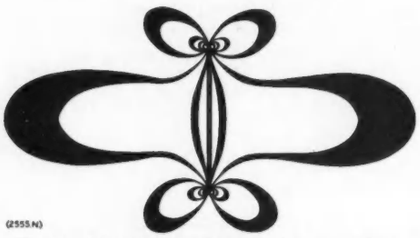


Fig. 10 The fringe pattern obtained experimentally for the specimen with a central slit; suitably aligned it will be found to compare closely with the theoretical pattern depicted in Fig. 3.

In case (*b*) the tension can be considered to be other than parallel to the minor axis by not putting $\beta = \frac{1}{2}\pi$. In this case the displacements at the end of the minor axis are given by:

$$\left.\begin{aligned} 8\mu u &= 2\,\mathrm{T}\,c\,(1+\kappa)\sin 2\beta \\ 8\mu v &= 2\,\mathrm{T}\,c\,(1+\kappa)(1-\cos 2\beta) \end{aligned}\right\}. \quad (3{\cdot}8)$$

The particular case $\beta = \frac{\pi}{4}$ gives $u = v$ and the previous analysis shows the maximum shearing stress to be given by:

$$4\tau^2 = \left[\frac{\mathrm{T}\,r\,c^2}{(r_1 r_2)^{\frac{3}{2}}}\right]^2 \left[\left\{-2\sin 2\theta + 6\sin\theta - \left(\frac{r^2}{c^2}\right)\sin 3\theta\right\}^2 + \left\{4\sin 2\theta + 2\cos 2\theta + 6\cos\theta - \left(\frac{r^2}{c^2}\right)\cos 3\theta\right\}^2\right]. \quad (3{\cdot}9)$$

This is a more complicated expression than before, but one from which τ could be computed.

(*c*) *Diametrically Opposite Forces at the Ends of the Minor Axis.*—The final case considered is that of some sort of wedge being forced into a crack in which case the problem becomes one of two equal and opposite forces $\mathrm{F}_1 = i\,\mathrm{Y}$ and $\mathrm{F}_2 = -i\,\mathrm{Y}$ at the ends of the minor axis.

In this case the complex potentials take the form[4]

$$\left.\begin{aligned} \Omega(\sigma) &= -\frac{2i\,\mathrm{Y}}{\pi}\log\left(\frac{\sigma - i}{\sigma + i}\right), \\ \omega(\sigma) &= -\frac{2i\,\mathrm{Y}z}{\pi}\log\left(\frac{\sigma - i}{\sigma + i}\right) - \frac{4a\,\mathrm{Y}}{\pi}\log\sigma \end{aligned}\right\}. \quad (3{\cdot}10)$$

so that, putting $\lambda = 1$ for the crack and substituting in the previous relations,

$$\tau^2 = \frac{\mathrm{Y}^2}{\pi^2 a^2}\,\frac{r^2 a^4 \sin^2\theta}{(r_1 r_2)^2}\left[4 + \frac{4}{r^2} + \frac{1 - 8x^2}{r^4}\right]. \quad (3{\cdot}11)$$

The variation of τ with x and y was plotted by using this formula and the results are shown in Fig. 4 on page 176.

4—SEMI-INFINITE PLATE WITH NOTCHED BOUNDARY

In the second part of this article the practical solutions of the problems of a semi-infinite plate (or sufficiently wide finite plate that may be considered semi-infinite) with a notched boundary are given; the notch taking the successive forms of semi-circle, semi-ellipse, and crack.

The corresponding problems do not so far seem to be capable of theoretical solution, but an interesting approximation to the case of the crack is afforded by the limiting case of the notched boundary given by the cubic curve (Fig. 5, page 176), the polar equation of which is

$$r = c\sec\theta - \lambda c\cos\theta \quad (\text{where } \lambda \leqslant 1). \quad (4{\cdot}1)$$

Variation of the parameter λ gives a series of curves of which the limiting case, $\lambda = 1$, has a cusp at the origin. This case gives an approximation to the problem of a crack on the boundary of a semi-infinite plate, and is relatively easily solved in that the boundary can be transformed into the unit circle by means of the conformal transformation

$$z = c\left[\tfrac{1}{2}\lambda\sigma + \frac{2}{\sigma} - 1\right]. \quad (4{\cdot}2)$$

Using this transformation, the case of the plate in a state of simple tension T at infinity has been shown by Stevenson[5] to be satisfied by the complex potentials

$$\Omega(z) = 2\,\mathrm{T}\,c\left[\frac{1}{\sigma} - \frac{\frac{1}{2}\lambda\sigma}{2 - \lambda}\right]$$

and

$$\omega(z) = 4\,\mathrm{T}\,c^2\left[\frac{1}{\sigma^2} - \frac{1}{\sigma} + \frac{3\lambda^2\sigma}{8(2-\lambda)}\right]$$

which, for the limiting case, $\lambda = 1$, become:

$$\left.\begin{aligned} \Omega(z) &= 2\,\mathrm{T}\,c\left(\frac{1}{\sigma} - \tfrac{1}{2}\sigma\right) \\ \omega(z) &= 4\,\mathrm{T}\,c^2\left(\frac{1}{\sigma^2} - \frac{1}{\sigma} + \frac{3\sigma}{8}\right) \end{aligned}\right\} \quad (4{\cdot}3)$$

with

$$z = c\left(\frac{\sigma}{2} + \frac{2}{\sigma} - 1\right).$$

Differentiating and substituting in equation (1·3) as before, gives

$$-2\Phi = \left(\frac{\sigma}{2} + \frac{2}{\sigma} - 1\right)48\,\mathrm{T}\left[\frac{\bar{\sigma}}{\bar{\sigma}^2 - 4}\right]^3 + 8\,\mathrm{T}\left[\frac{16 + 10\,\bar{\sigma}^2 - 12\,\bar{\sigma}^4}{(4 - \bar{\sigma}^2)^3}\right]. \quad (4{\cdot}4)$$

Now, using the polar co-ordinates defined by

$$z = r\,e^{i\theta}, \quad z - c = r_1\,e^{i\theta_1}, \quad z + 3c = r_2\,e^{i\theta_2},$$

so that

$$[(z-c)(z+3c)]^{\frac{1}{2}} = (r_1 r_2)^{\frac{1}{2}}\,e^{\frac{1}{2}i(\theta_1+\theta_2)} = \frac{c}{2}\,\frac{\sigma^2 - 4}{\sigma},$$

then expression (4·4), after some simplification, becomes

$$-2\Phi = \frac{6\,\mathrm{T}\,c^2 r\,e^{i\theta}}{(r_1 r_2)^{\frac{3}{2}}\,e^{-\frac{3}{2}i(\theta_1+\theta_2)}} + \left\{\frac{2\,\mathrm{T}\,c^3}{(r_1 r_2)^{\frac{3}{2}}\,e^{-\frac{3}{2}i(\theta_1+\theta_2)}} \times \left[\left\{\frac{3}{2} + \frac{r\,e^{-i\theta}}{2c} - \frac{(r_1 r_2)^{\frac{1}{2}}\,e^{-\frac{1}{2}i(\theta_1+\theta_2)}}{2c}\right\}^2 + 3\left\{\frac{3}{2} + \frac{r\,e^{-i\theta}}{2c} - \frac{(r_1 r_2)^{\frac{1}{2}}\,e^{-\frac{1}{2}i(\theta_1+\theta_2)}}{2c}\right\} + 7\right]\right\},$$

and separating the real and imaginary parts of this expression the stresses are found to be given by.

$$\begin{aligned} \widehat{yy} - \widehat{xx} = \frac{\mathrm{T}\,c^3}{(r_1 r_2)^{\frac{3}{2}}}\Big[&\frac{3r}{c}\cos\tfrac{1}{2}(2\theta + 3\theta_1 + 3\theta_2) \\ &+ \frac{29}{8}\cos\tfrac{1}{2}(\theta_1 + \theta_2) \\ &- \frac{9r}{8c}\cos\tfrac{1}{2}(-2\theta + 3\theta_1 + 3\theta_2) \\ &+ \frac{3r^2}{8c^2}\cos\tfrac{1}{2}(-4\theta + 3\theta_1 + 3\theta_2) \\ &+ \frac{9(r_1 r_2)^{\frac{1}{2}}}{8c}\cos(\theta_1 + \theta_2) \\ &+ \frac{3r_1 r_2}{8c^2}\cos\tfrac{1}{2}(\theta_1 + \theta_2) - \frac{(r_1 r_2)^{\frac{3}{2}}}{8c^3} \\ &- \frac{9r(r_1 r_2)^{\frac{1}{2}}}{4c^2}\cos(-\theta + \theta_1 + \theta_2) \\ &+ \frac{3r r_1 r_2}{8c^3}\cos\tfrac{1}{2}(-2\theta + \theta_1 + \theta_2) \\ &- \frac{3r^2(r_1 r_2)^{\frac{1}{2}}}{8c^3}\cos(-2\theta + \theta_1 + \theta_2)\Big], \end{aligned}$$

and

$$\begin{aligned} -2\,\widehat{xy} = \frac{\mathrm{T}\,c^3}{(r_1 r_2)^{\frac{3}{2}}}\Big[&\frac{3r}{c}\sin\tfrac{1}{2}(2\theta + 3\theta_1 + 3\theta_2) \\ &+ \frac{29}{8}\sin\tfrac{1}{2}(\theta_1 + \theta_2) \\ &- \frac{9r}{8c}\sin\tfrac{1}{2}(-2\theta + 3\theta_1 + 3\theta_2) \\ &+ \frac{3r^2}{8c^2}\sin\tfrac{1}{2}(-4\theta + 3\theta_1 + 3\theta_2) \\ &+ \frac{9(r_1 r_2)^{\frac{1}{2}}}{8c}\sin(\theta_1 + \theta_2) \\ &+ \frac{3r_1 r_2}{8c^2}\sin\tfrac{1}{2}(\theta_1 + \theta_2) \\ &- \frac{9r(r_1 r_2)^{\frac{1}{2}}}{4c^2}\sin(-\theta + \theta_1 + \theta_2) \\ &+ \frac{3r r_1 r_2}{8c^3}\sin\tfrac{1}{2}(-2\theta + \theta_1 + \theta_2) \\ &- \frac{3r^2(r_1 r_2)^{\frac{1}{2}}}{8c^3}\sin(-2\theta + \theta_1 + \theta_2)\Big]. \end{aligned}$$

These two expressions can then be used as before to give the maximum shearing stress at any point.

PHOTO-ELASTIC INVESTIGATION

The tests were carried out firstly to compare the results for a slit in a theoretically infinite plate (the analysis of which has already been given) with those of a practically finite plate, and so justify the replacement of the former by the latter and vice versa, subject to a certain mini-

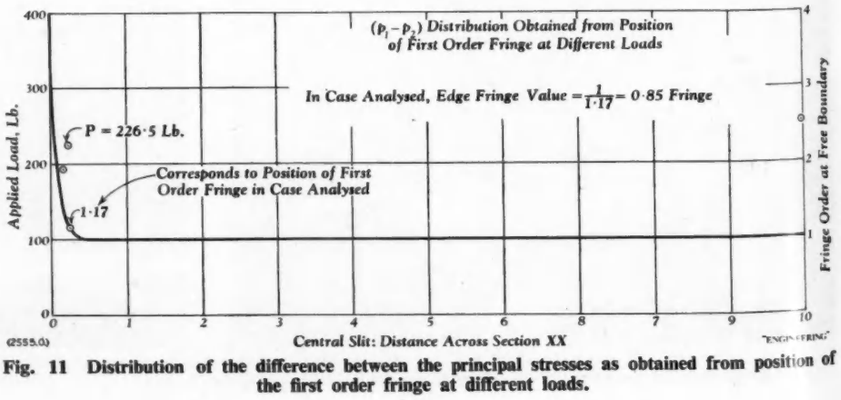

$(p_1 - p_2)$ Distribution Obtained from Position of First Order Fringe at Different Loads
In Case Analysed, Edge Fringe Value = 1/1·17 = 0·85 Fringe
P = 226·5 Lb.
Corresponds to Position of First Order Fringe in Case Analysed
1·17
Applied Load, Lb.
Fringe Order at Free Boundary
Central Slit: Distance Across Section XX
(2555.O)
"ENGINEERING"

Fig. 11 Distribution of the difference between the principal stresses as obtained from position of the first order fringe at different loads.

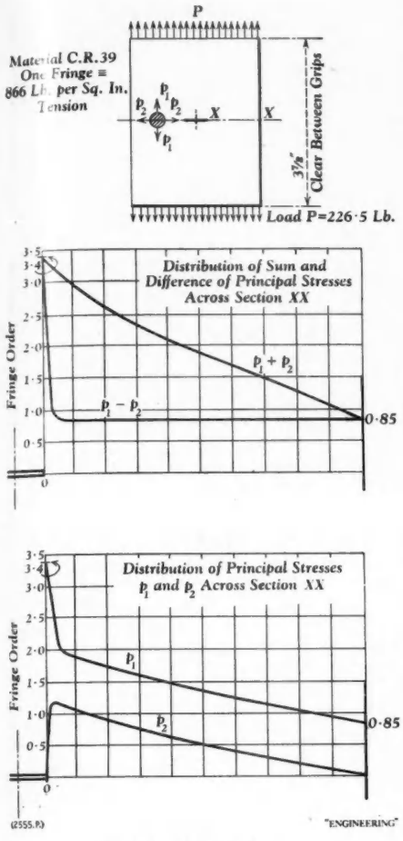


Fig. 12 Central slit.

Figs. 12 to 16 Show the distribution as determined by experiment of the sum and difference between the principal stresses and of the principal stresses for the five specimens considered.

mum width of the practical plate; and secondly to obtain stress concentration factors and stress distributions across one section of symmetry in practically semi-infinite plates in simple tension but having different discontinuities in one edge.

Specimens.—All specimens were cut from Columbia resin sheet (C.R. 39), ¼ in. thick. The dimensions of the five specimens tested are shown in Fig. 6, page 177. The range of $\frac{r}{d}$ was 0·11 to 0·003 for corresponding ratios of $\frac{D}{d}$ from 1·11 to 1·20, where $2r$ = maximum breadth of discontinuity, d = minimum width of specimen through discontinuity, and D = maximum width of specimen (Fig. 6). The depth of the edge notch $(D - d)$ is denoted by the letter t. In the case of the semi-elliptical notches, the ratios of the major axis to the minor axis were 3·25 and 1·87 for the small and large notches respectively. The dimensions of the calibration specimen are shown in Fig. 7.

The specimens were cut on a pantograph engraving machine, using enlarged templates for the profiles of the semi-circular and semi-elliptical notches. The straight edges were produced by feeding the machine table, with the specimen attached, past the cutter. Small cuts with slow feeds were employed, and ordinary machining coolant was applied at the tool tip. The slit type discontinuities were produced by means of jewellers' circular and piercing saws, and fine drills. After machining, the specimens were washed in soapy water, rinsed and polished dry.

Specimen Grips.—The specimens were gripped in serrated steel grips with strips of coarse emery cloth as friction material between the steel and the specimen. This adequately distributed the clamping force across the width of the specimen and gave satisfactory distribution of the tensile load. Links were used to fit this assembly into the straining frame which was arranged for tensile loading.

PHOTO-ELASTIC POLARISCOPE

The tests were carried out in the polariscope shown in Figs. 8, on page 177; it was designed and constructed at the Royal Technical College, Glasgow.

The optical system is composed of 5-in. aperture compound collimating and collecting lenses, of 12-in. focal length, the collecting lens having a built-in shutter. The lamphouse contains a 10-volt, 240-watt compact-source tungsten-filament pre-focus lamp and a 250-volt, 500-watt compact-source mercury-vapour pre-focus lamp. A reflector and a 24-volt direct-current fan are also installed. Wratten No. 77 and No. 58 filters are employed to isolate the mercury green line when required. A half-plate camera without lens or shutter is used for the photography of the fringe patterns.

The straining frame may be arranged for tensile or compressive loading, the load being applied through a lever system. The load is applied by a water-loading tank, the rate of loading or unloading being variable. For demonstration work, the fringe pattern is projected on to a movable projection screen 3 ft. square, and if isoclinics are to be sketched, a viewing cabinet with a mirror system and a 2-ft. square ground-glass screen is employed. In conjuntion with the viewing cabinet, a photo-electric photo-multiplier (R.C.A. 931-A) is used for scanning the fringe pattern and for the Tardy method of compensation for fractional fringe values.

A control cabinet houses the various transformers and chokes required for the lamps, also a direct-current power pack and an electric shutter timing unit.

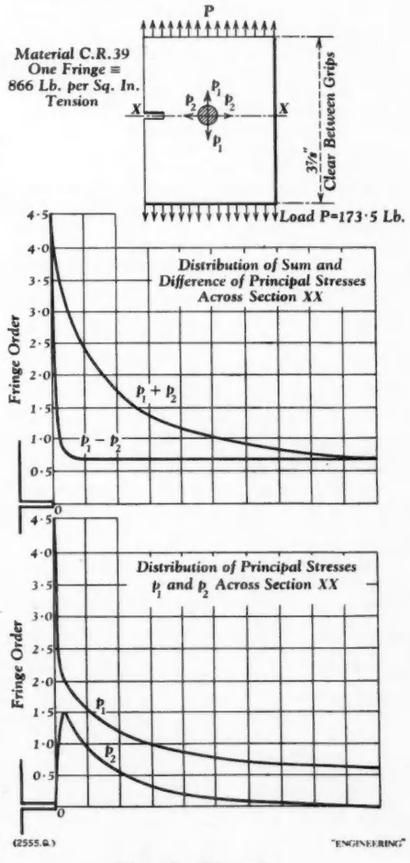


Fig. 13 Edge slit.

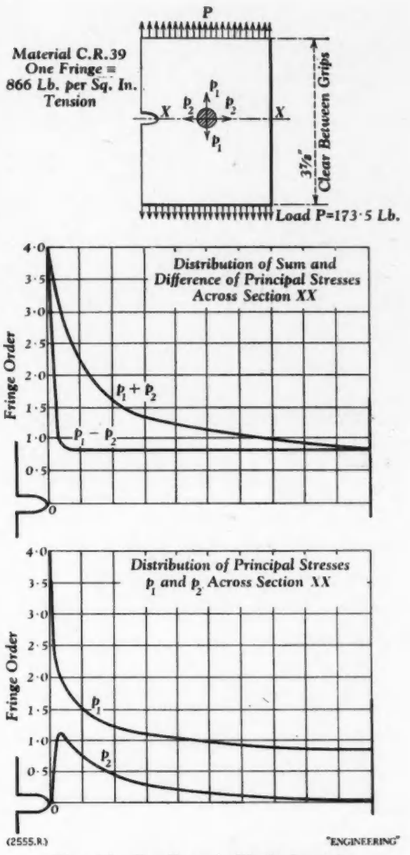


Fig. 14 Small semi-elliptical notch.

THE "FRINGE-TRAVEL" TESTING TECHNIQUE

The various specimens were tested in tension for a series of loads, in monochromatic light. Photographs of the fringe patterns were taken at each load within as short a period of loading as possible, to minimise the effects of creep.

In each test, the first-order fringe positions and corresponding loads were noted as this fringe moved from the notch to the outer boundary. These readings were used to determine the distribution of principal stress difference by the "fringe travel method" as described below.

Since the discontinuities in the specimens were sharp, or on one edge, it was not possible to load the specimens to give a large number of fringes across the horizontal section of symmetry through the discontinuity. This made the determination of the distribution of principal stress differences difficult. A novel method to do this easily, based upon a treatment similar to brittle lacquer work by Durelli[6] was suggested by Dr. Kenedi.*

An isochromatic (or fringe) may be considered as a locus of constant principal stress difference. If elastic behaviour is assumed, the fringe order at any point is directly proportional to the load applied, that is $n \propto W$ where n is the fringe order and W the applied load.

Therefore, at a given point in a section, if the fringe order is n_1 corresponding to a load W_1 then the fringe order n_2 at this same point corresponding to a load W_2 will be $n_2 = n_1 \times \frac{W_2}{W_1}$. Consider any section, say AD in Fig. 9, and let the position of the first-order fringe be known for a series of loads W_A to W_D so that this fringe travels from A at W_A to D at W_D. At any intermediate load W_B, let the first-order fringe be at B.

Then n_A = principal stress difference at A for load $W_D = n_1 \times \frac{W_D}{W_A}$,

* Of the Royal Technical College, Glasgow.

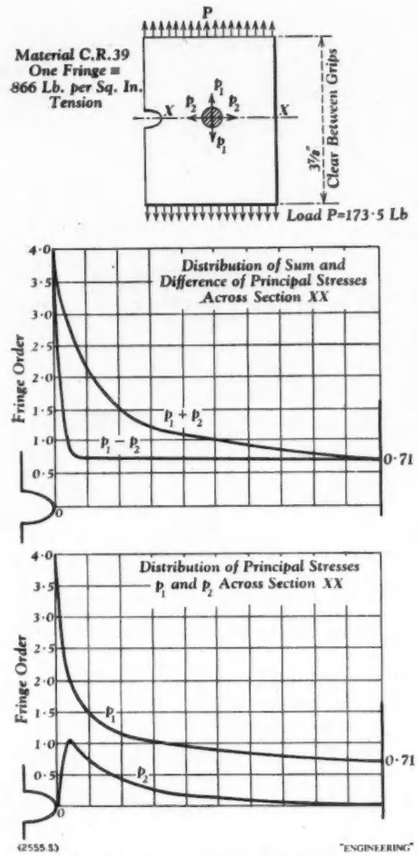


Fig. 15 Large semi-elliptical notch.

and n_B = principal stress difference at B for load $W_D = n_1 \times \frac{W_D}{W_B}$.

If the material is calibrated and the model fringe value obtained, then n_1 may be taken as the model fringe value, since the travel of any fringe may be used in the foregoing procedure. Thus for any given load, the appropriate distribution may be obtained.

Calibration.—The material was calibrated in the normal way by loading a tensile strip in circularly polarised monochromatic light and noting the loads at each integral fringe order.

PRINCIPAL STRESS ANALYSIS

Having obtained the distribution of principal stress difference (p_1-p_2) for the horizontal section through the discontinuity, the distribution of the sum of the principal stresses $(p_1 + p_2)$ was found by calculation, using the numerical solution of Laplace's equation by the iterative process.[7]

Values of $(p_1—p_2)$ and $(p_1 + p_2)$ were plotted for this section and the separate values of p_1 and p_2 were obtained by addition and subtraction.

Stress Concentration Factors.—The stress concentration factor is defined as

$$K = \frac{\text{Max. stress in section through discontinuity}}{\text{Nominal average stress in section through discontinuity}} = \frac{n_{max.} \times F}{\frac{P}{A}}$$

where $n_{max.}$ = maximum fringe order,
F = model fringe value in lb. per square inch tension,
P = resultant axial load on model, and
A = minimum area of section through discontinuity.

The values of K are given in the table below.

The fringe pattern for the central slit specimen at the highest load is shown in Fig. 10. The details of the calibration specimen are.—

Cross-sectional area of specimen = 0·103 square inch.

Load when fringe order is 3 = 267 lb.

Therefore model fringe value $= \frac{P}{An} = \frac{267}{0·103 \times 3}$ = 866 lb. per square inch per fringe (tension).

The distribution of principal stress difference for the central slit specimen is shown in Fig. 11, on page 178. This was obtained by the fringe travel method. The complete analysis for this specimen is shown in Fig. 12, and for the other four specimens in Figs. 13, 14, 15, and 16.

DISCUSSION OF RESULTS

Fringe Patterns.—For the area of the central slit specimen under consideration, the photo-elastic fringe pattern, shown in Fig. 10, agrees with the theoretical fringe pattern shown in Fig. 3, on page 176. The division of the loops in the fringe pattern takes place as predicted by the theory. The upper half of any loop from one end of the slit moves round to combine, at the centre line, with the corresponding half-loop from the other end of the slit. These form a closed loop on the vertical centre-line and then decrease in size with increase of load. A corresponding loop is formed below the slit.

On the horizontal section through the slit, the half loop from above the section straightens out and merges with the corresponding half-loop from below the slit. Since the theory has treated the central crack as the limiting case of an ellipse, it is reasonable to compare the fringe pattern for the crack with the fringe pattern for a specimen containing a central circular hole, which is a special form of ellipse.[7] This comparison shows the expected similarity of distribution.

The fringe patterns for the specimens with edge notches were similar in form, the maximum fringe order at the notch for a given load, increasing with the sharpness of the notch.

Stress Distributions.—The general form of the graphs showing the distribution of the principal stresses p_1 and p_2 is similar to that for tensile specimens with deep grooves, one on each side of the specimen[8, 9].

Stress Concentration Factors.—In the central slit case, the value of K = 4·08 may be compared with the value of K = 3·00 which is the theoretical stress concentration factor for a central hole in an infinite plate[7, 8]. For the edge notch specimens, the stress concentration factors increase as the ratio $\frac{r}{t}$ decreases. In these cases the parameter $\frac{r}{t}$ was altered by changing the dimension r and the shape of the notch.

The concentration factor of 4·22 for the semi-circular notch may be compared with Maunsell's factor of K = 3·05 for a similar notch in an infinite plate[10].

All the stress concentration factors obtained from the tests described are of the same relative order as those quoted by Durelli[6] for infinitely wide plates of similar $\frac{D}{d}$ and $\frac{r}{t}$ ratios, but are in general higher.

STRESS CONCENTRATION FACTORS

Specimen	$\frac{D}{d}$	$\frac{r}{d}$	$\frac{r}{t}$	$n_{max.}$	P lb.	A sq. in.	K
Central slit	1·20	0·0030	—	3·4	226·5	0·313	4·08
Edge slit	1·11	0·0037	0·033	4·5	173·5	0·338	7·65
Small semi-ellipse	1·11	0·034	0·307	4·0	173·5	0·338	6·75
Large semi-ellipse	1·11	0·0615	0·553	3·5	173·5	0·338	5·90
Semi-circle	1·11	0·111	1·00	2·5	173·5	0·338	4·22

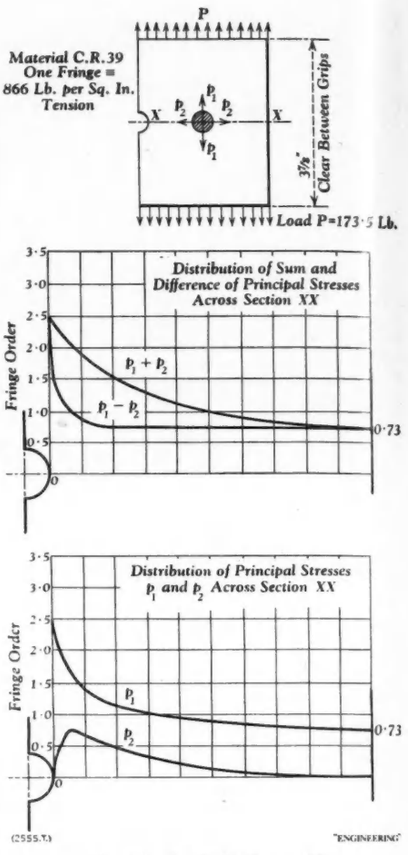


Fig. 16 Semi-circular notch.

Errors in Values of K.—As pointed out by Frocht[9] the major errors in K are due to errors in the value of maximum fringe order. For small values of $\frac{r}{t}$ the errors in the maximum fringe order may be considerable, since the large stresses at the sharp notches are confined to a very small space. The fringes are, therefore, crowded and have a sharp gradient at the notch. This causes the determination of the maximum fringe value to be extremely difficult.

The figures given for K, therefore, should be regarded as minimum values and, in the cases of very sharp discontinuities, may be considerably conservative.

Acknowledgments.—The authors are grateful to Mr. A. C. Stevenson for allowing them to use his unpublished results, equations (2·3), (2·4) and (3·1); to Professor A. S. T. Thomson for the use of the Photo-elastic Laboratory of the Royal Technical College, Glasgow; and to Dr. R. M. Kenedi for his help in the photo-elastic analysis.

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[5] A. C. Stevenson, *Phil. Mag.*, vol. 36, pages 183-5 (1945).
[6] A. J. Durelli, *Proc. Soc. Exp. Stress Analysis*, vol. 6, No. 2, pages 68-83 (1949).
[7] M. M. Frocht, *Photoelasticity*, vol. 2, pages 254-255 (1948).
[8] M. M. Frocht, *Photoelasticity*, vol. 1, pages 227-239 (1946).
[9] M. M. Frocht, *Proc. Soc. Exp. Stress Analysis*, Vol. VIII, No. 2, pages 171-186 (1951).
[10] F. G. Maunsell, *Phil. Mag.*, vol. 21, pages 765-773 (1936).

Fig. 1 Hinged steel clips are used to connect lengths of the ducting which are stiffened at the ends by steel hoops.

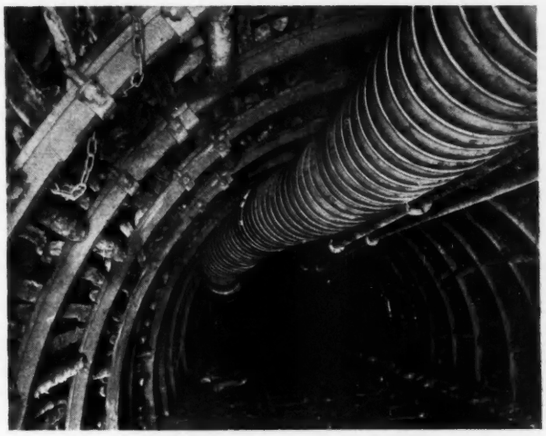


Fig. 2 Type "S" ducting is reinforced by helical steel wire and is best suspended using guide ropes.

FLEXIBLE PLASTICS DUCTING FOR MINE WORKINGS

Ducts carrying ventilating air to the neighbourhood of the working face in mines are frequently subjected to unfavourable atmospheric conditions and may have to be installed in awkward situations. Ideally, ducting should be readily portable and easy to fix. It should resist corrosion and rotting, and should be non-inflammable. In addition, its internal surface should be smooth and uniform in order to minimise friction losses. The ducts commonly in use are either of metal or fibre construction. Both of these types satisfy one or more of these requirements, but each carries some disabilities. A flexible plastics ducting, which has been given the name Flexadux, is claimed to meet them all and both tests and practical experience appear to justify this claim.

Flexadux is made from polyvinyl-chloride plasticised with tricresyl phosphate. It has a wall thickness of 0·025 in., is rot proof and age resistant, will not support combustion and has a tensile strength of 3,200 lb. per square inch. It may be installed in situations ranging in temperature from 25 deg. C. below zero to 60 deg. C. above. In case of damage, the material can be repaired by hand-welding with an electric iron. Flexadux is manufactured in three types, two of circular cross section and one flat; this latter is intended only for emergency use. The circular-section ducts are supplied in standard 13-ft. lengths, although other lengths can be furnished. The ends of the 13-ft. lengths are reinforced by steel rings on the outside so that an un-interrupted smooth surface is maintained inside. The lengths are connected together by hinged clips which embrace the stiffening rings. The arrangement is shown in Fig. 1. The clips are provided with locking levers and no tools are necessary when making a connection.

Two types of circular-section Flexadux are made. Type "S," illustrated in Fig. 2, is reinforced by a continuous helical steel wire which is enclosed in a plastics covering to prevent corrosion. It is available in standard diameters ranging from 8 in. to 32 in. This form of Flexadux is suitable for use under either positive or negative pressures up to 20 in. water gauge. Type "B," with standard diameters ranging from 8 in. to 24 in., is reinforced by circular steel rings and is suitable for use only for positive pressures of 20 in. water gauge. The flat type shown folded in Fig. 3 and intended for temporary use, is flexible and is supplied in diameters of 8 in. and 12 in. and in lengths up to 150 ft. The ends are stiffened with steel rings and lengths may be coupled together by interlocking the rings with a clip. Flexadux is best installed by suspending it from guide ropes in the manner shown in Fig. 2. The ropes should be fixed to the roof supports, or roofing, at intervals of from 25 to 30 ft. Hooks are provided on the ducts for connection to the guide ropes. Sleeves can be supplied to connect Flexadux to metal ducts, or a fan casing, and tee pieces, or other special forms can be made up.

Flexadux has been in service in Continental mines for four years and it is claimed that installation in German and French mines is now proceeding at a rate of approximately a quarter of a million feet per annum. A report on the behaviour of Flexadux installed underground in the Heinrich and Theodore Mine, Essen, Western Germany, states that the pressure loss per 100 m. length of metal ducting 500 mm. in diameter exceeded by 13 per cent. the loss from Flexadux of the same diameter installed in the same ventilation line and that the quantity loss for metal ducts varied from 5 per cent. to 27 per cent., depending on their condition, whereas the air loss from Flexadux was only 0·5 per cent.

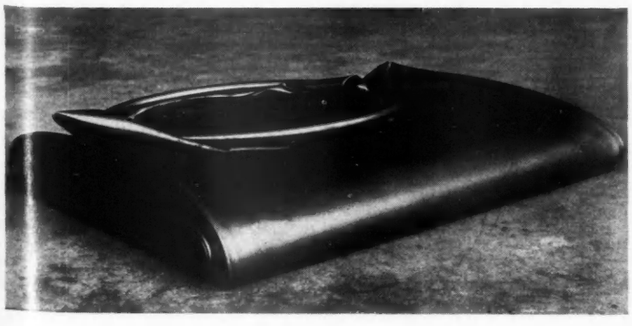


Fig. 3 The casing of Flexadux is made from P.V.C. plasticised with tricresyl phosphate. Unreinforced, the ducting can be folded flat but in this form it is intended only for temporary use.

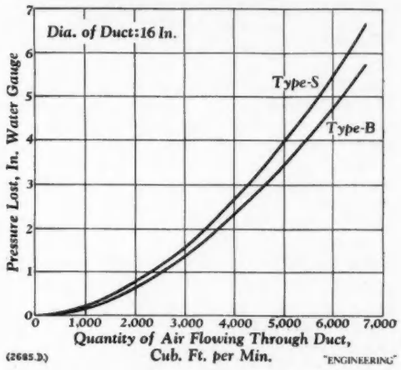


Fig. 4 Pressure drop along a 330-ft. length of ducting for different air flows.

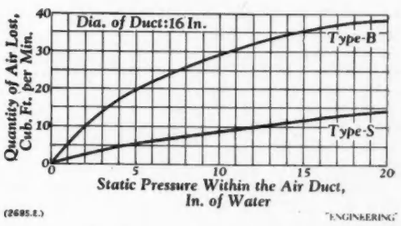
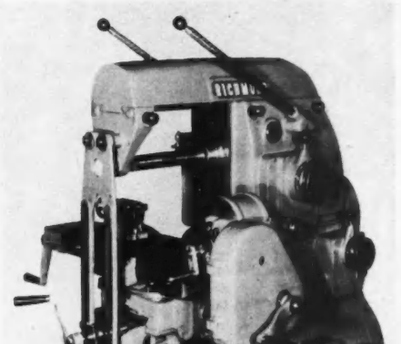


Fig. 5 Air losses, by volume, at different pressures from a 330-ft. length of ducting.

Figs. 4 and 5 are diagrams giving the results of laboratory tests of Flexadux for loss of pressure and leakage, carried out in Germany. For evaluating the pressure loss, a 330-ft. length of Flexadux. 16 in. in diameter, was connected to an air supply through a metal pipe containing an orifice plate for calculating the quantity of air flowing. The static pressure was measured at various flow quantities by a pilot tube. To measure quantity losses, a 330-ft. length of Flexadux, closed at both ends, was maintained at various pressures, the quantity of air supplied giving a measure of the leakage loss. It will be seen from the diagrams, that from the point of view of pressure loss there was little difference between Type "S" and Type "B," and that while the quantity loss from Type "B" up to a pressure of 20 in. water gauge was small, Type "S" could be looked upon, for practical purposes, as approaching perfect sealing. The manufacturing rights for Flexadux in the United Kingdom are held by Wilkinson Rubber Linatex, Limited, Camberley, Surrey.



This " Richmond " milling machine is an addition to a well-known range. It has a 30-in. by 8-in. worktable and twelve spindle speeds. There are also twelve power feeds.

ALL-GEARED MILLING MACHINE

Addition to " Richmond " Range

Midgley and Sutcliffe, Limited, Hillidge Works, Leeds, 10, have introduced the machine illustrated herewith as an addition to their " Richmond " range of milling machines.

The machine table has three T-slots and a working surface of 30 in. by 8 in. It can be swivelled up to 45 deg. on either side of the centre-line. A vertical hand-operated adjustment of 15 in. is provided. The maximum longitudinal and cross traverse movements, both of which can be made by hand or under power, are 18 in. and 6 in., respectively, and they are equipped with adjustable trip-dogs. A " Richmond " 4-in. universal dividing head is supplied as standard equipment.

The spindle is of alloy steel, hardened and ground, with a bore to No. 40 National Steep Taper, and carries a 1-in. diameter cutter arbor. It is mounted in a pair of Timken taper roller bearings at the front and a roller bearing at the rear. A 2-h.p. electric motor running at 1,450 r.p.m. is mounted on a hinged base in the body of the machine, and four V-belts are used to drive the pulley shaft. Control is through a double-disc type friction clutch, one side of which acts as a brake for the spindle. Twin levers, one at each side of the machine, are used to operate the clutch, and the motor is started and stopped by a flush-mounted push-button switch fitted in the machine body. A flush-mounted isolating switch is provided adjacent to the push-button control.

There are 12 spindle speeds, ranging from 30 to 700 r.p.m., in geometrical progression, the gearbox having nickel-chrome steel gears, hardened and profile-ground. Speed changes are made through sliding gears on high-carbon steel splined shafts. All the gear shafts are carried in ball and roller bearings. Twelve feeds are available, independent of the spindle speeds, the range being from $\frac{1}{2}$ in. to 12 in. per minute. Changing the feeds is also effected by sliding gears on ground splined shafts with ball bearings. The speeds and feeds are each controlled by a lever and disc mounted on the machine body, the speed or feed chosen being indicated on a graduated dial.

A mechanical oil pump supplies lubricating oil for all gears and bearings, the oil passing through a sight-feed glass. There is a gear-type suds pump enclosed in the body, to supply coolant to the cutters.

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OIL-FIRED AIR HEATER

Compact 125,000 B.Th.U per Hour Industrial Unit

A new oil-fired air heater for industrial premises, of low installation cost, providing instant warming up after switching on, and with the ability to operate for comparatively long periods without servicing, has been developed by A. G. Greaves and Son, Limited, 141 Elm-grove, Southsea, Hampshire. The floor-mounted unit shown in the illustration below develops 125,000 B.Th.U. per hour and will adequately heat 2,500 square feet of floor area in an average factory. It has a thermal efficiency of 70 per cent., an air throughput of 550 cub. ft. per minute, and consumes one Imperial gallon of fuel per hour. The recommended fuel is gas oil with a viscosity of 40 seconds Redwood No. 1 with Diesel oil, paraffin, or tractor-vaporising oil as alternatives.

In the floor heater unit illustrated, the working parts are enclosed in a sheet-metal cabinet. The lower half of the casing is occupied by the fan and fuel system. The fan impeller is mounted directly on the motor shaft, and the fuel pump is belt-driven from a projecting shaft at the opposite end of the motor. A belt guard is fitted.

The air-heater component, bolted to the top of the fan, consists of a pressure-jet burner firing into a steel combustion chamber. The combustion chamber forms the first pass of the heat exchanger, the second pass being in the form of an outer annulus, returning the combustion gas to twin flue pipes emerging from the end panel not visible in the illustration. The use of twin flue pipes ensures an even distribution of hot gases within the heat exchanger. The flue pipes are connected to the main 4-in. outside diameter flue duct, supplied as a standard item. The ventilating air, drawn in from ground level, flows upwards at high velocity and around the two passes of the heat exchanger, and thence through the discharge grille on top of the casing. The grille has adjustable vanes and damper. A small proportion of the cold air from the fan is used to supply the burner with air for combustion. The burner is completely outside the ventilating air passages and no fuel pipes pass anywhere through the ventilating air stream.

The burner is controlled by a constant-pressure valve in the fuel pump, the amount of fuel burned depending upon the setting of the valve and the size of atomising nozzle fitted. The standard size of jet gives a fuel flow of 1 gallon per hour, working at 200 lb. per square inch pressure.

A high-voltage transformer causes automatic ignition by producing a continuous arc which is blown into the atomised fuel spray by the combustion air. The continuous-ignition arc ensures re-ignition should there be a momentary stoppage in the fuel supply.

Included in the standard fuel system is a hand-controlled shut-off valve and a fuel filter, both on the suction side of the fuel pump. A $\frac{3}{8}$-in. fuel pipe projects from the end panel of the unit and is intended to be connected by means of oil-resisting rubber hose and iron or copper pipe to the main fuel storage tank. On the pressure side of the fuel pump, an electrically-operated shut-off valve controls the supply of fuel to the burner. This valve is wired to one of the electrical starters on the end panel.

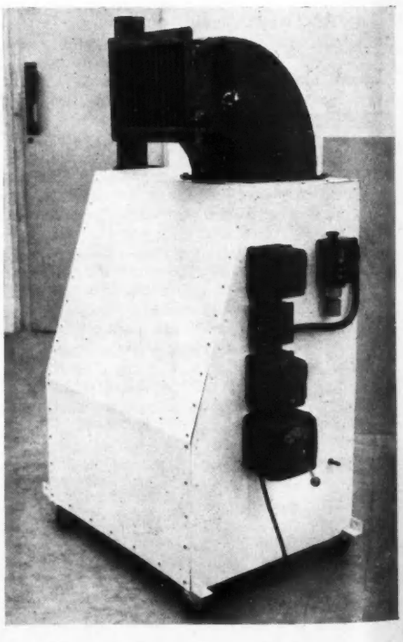
Units fitted with high-low flame control have an extra electrically-operated valve wired to a room thermostat or switch. This valve brings into action an additional constant-pressure valve which is located in the pipe-line on the pressure side of the fuel pump; the setting of the additional valve provides the low-heat fuel pressure.

To give complete safety, two thermostats are fitted in the outlet from the heater. One of these is set to switch off the heater if the temperature should reach 130 deg. C., and thus guards against overheating; the normal operating temperature depends upon the external air temperature, but should not exceed 110 deg. C. The second thermostat is set to close the fuel system circuit at 30 deg. C., should the burner fail to ignite, and thus prevents excessive fuel from flooding the combustion chamber. The small amount of unburnt fuel passing into the chamber on such an occasion would be drained into the drip tray beneath the unit. A drain trap is located in the combustion air tapping so that on no occasion can fuel drain back into the ventilating ducting. Access to the unit for maintenance is through a sliding panel in the rear of the unit and, in addition, all panels of the cabinet are detachable.

On the standard unit, there is provided one electrical starter for the fan and another for the heater. The controls for these, together with the main isolator switch fuse, are located on the end panel. With this system, the heater starter button must be held in for a period of 20 seconds to give the flame-failure thermostat time to warm up. For ventilation in the summer, this unit may be used with the fan running without the heater in operation.

Alternative control systems can be provided, which embody an oil-burner control box and enable the unit to operate fully automatically from a time clock or thermostat. With each system, a high-low flame control can be supplied as an extra fitting, this giving either full or 50 per cent. of full heat; this system is controllable either by a room thermostat or by a hand switch.

The same basic design of combustion heater as embodied in the floor unit can be supplied for marine installations with suitable air inlet and outlet ducts, the heater itself in this case being separate from the fan and controls and included as part of the ducting. A system is also available for larger industrial installations in which several overhead combustion heaters are suspended at intervals along an overhead duct supplied with cold air from a large external fan. In such a system, no floor space is required, and heat is not dissipated wastefully through the wall of the main air duct.



Floor-mounted air-heating unit with a pressure-jet oil burner firing into a steel combustion chamber forming the first pass of a two-pass heat exchanger. Ventilating air is drawn in at floor level and after passing through the heat exchanger emerges through the adjustable grille.

NEW MECHANICAL SHOVEL

Non-Metallic Turntable Bushes

A number of new features in respect of materials and design layout have been embodied in the latest excavator to be introduced by Newton Chambers and Company, Limited, Thorncliffe, near Sheffield. The new model, recently shown at a series of demonstrations given in the company's grounds, and illustrated below, is the ½-cub. yd. NCK 205. Like its predecessors, the 304 (¾-cub. yd.) and the 605 (1½-cub. yd), it has been designed and manufactured in association with the Koehring Company of Milwaukee, U.S.A. Since Newton Chambers and Company began building excavators at Thorncliffe in 1947 nearly 1,000 machines have gone to work in the United Kingdom and in 30 countries overseas.

As already noted, a number of features new to the company's machines have been included in the "205." Non-metallic bushings have replaced bronze bushes on the turntable hook rollers and are expected to give a longer life. An improved layout of the operating levers and pedals has been obtained, which is expected to reduce driver fatigue and yet simultaneously permit faster working cycles. The crawler frame of the new model consists of cross beams bolted to the side members; this provides a small amount of "give" in the assembly which permits a little distortion and counteracts any tendency to crack that may be present in solid castings or at the welded junctions in fabricated units. Such a form of construction also allows the overall width of the crawler frame to be increased without other modification when ground conditions require greater stability.

The features which have been successfully used on the "304" and "605" and are repeated in the new model include: self-cleaning tumblers, smooth-faced shoes with full-width hinges, rust-proofed adjusters, and inverted U-shaped members which overcome the problem of dirt collecting and fouling the tracks.

The NCK 205 is available with drag shovel, face shovel, skimmer, dragline, crane and crane-grab attachments and conversions from one type to another are quickly and easily made in the field. The face-shovel model employs a 16-ft. welded box-section boom with a 12 ft. 2 in. single dipper stick, and the bucket is fitted with a manganese-steel front.

With the drag-shovel attachment shown in the illustration, trenches can be dug to a depth of 17 ft. 9 in. and the spoil discharged at a height of 10 ft. The ½-cub. yd. bucket is 32 in. wide over the side cutters. The skimmer attachment uses a standard drag-shovel boom and operating mechanism. By means of a special extended runway which can be quickly attached to the boom, a level cut of 12 ft. can be obtained, together with a discharge height of 16 ft. 10 in. The bucket door is controlled by the electric trip mechanism used for discharging the shovel dipper bucket.

The dragline, crane and crane-grab attachments require the use of a lattice boom constructed from four chord angles with diagonal lacings, and boom lengths of 30 to 50 ft. can be built up using extension pieces either 5 ft. or 10 ft. long. When equipped for crane duty, the NCK 205 has a maximum lifting capacity of 7½ tons, but a 15-ft. long boom jib with a single line hook can be fitted to give an increased outreach and faster operation.

* * *

DROP TANKS OF PLASTICS

Standard Range for Service Aircraft

The Bristol Aeroplane Company, Limited, Filton, Bristol, is to produce a standard range of plastics drop tanks as the result of orders from the Ministry of Supply.

Plastics has been chosen to replace aluminium alloys for these drop tanks because of the need to economise in cost and in strategic materials. The first cost of the plastics tank is generally estimated to be 25 to 30 per cent. less than that of its equivalent in aluminium. In some cases the saving can be much greater—the percentage varying according to the design of the tank and the scale of production. Standard tanks are being called for because of the high rate of output which may be required, the economy in labour and cost, and the easing of supply problems.

The standard sizes so far developed at Bristol have the following capacities: 50, 100, 150, 200, 300 and 500 gallons. The front and rear shells of the 100- and 150-gallon drop tanks are the same; the larger tank has greater capacity through having a longer centre shell. The 200 and 300-gallon tanks also have common front and rear shells.

The techniques developed for primary structures—the moulding of cylindrical fuselage sections by the autoclave process and hydraulic-press moulding methods used for wing sections and frames—have proved adaptable for the manufacture of drop tanks, the former for the shell and the latter for the internal framework.

All the tanks consist of three main shell sections—an elliptical nose shell, a parallel centre shell carrying the attachment points, and a tapered rear shell—with high-pressure moulded internal frames assembled by hot glueing. The complete manufacturing process has been planned with the object of using the simplest possible tools and processes, so that it is not necessary to use elaborate plant or skilled labour for production. The basic aerodynamic shape of the standard tanks was the work of the Royal Aircraft Establishment, Farnborough, but the structural design, manufacturing methods and tooling processes have been entirely developed at Bristol and are covered by Company patents.

ADJUSTABLE FIN FITTED

Good jettison characteristics are ensured by fitting a fin which is designed to counteract any pitching moment so that the tank falls away from the aircraft in a horizontal attitude when it is empty. The fin is adjustable on the ground so that the correct incidence can be set for the dropping characteristics of any particular aircraft.

Provisioni s made for various types of air/fuel connection to be screwed into the tank ports to meet the requirements of varying designs. An automatic float-switch can also be fitted which cuts off the fuel supply when the tanks are full if pressure-fuelling is being used instead of gravity feed. The pick-up point on the tank is designed to fit on the standard bomb or under-wing stores attachment-point of military aircraft. The pick-up can readily be adapted to fit the two-lug American-type mounting or a jettison gun mounting.

The standardised plastics drop tanks going into production at the Bristol Aeroplane Company are made in three sections bolted together for ease of storage and assembly.

Plastics tanks can be manufactured to give a finer surface than aluminium tanks, and the outer surface can be painted in any finish or camouflage required. Tests have shown the plastics used for the tanks to be unaffected by extremes of temperature and humidity. A metal cap, moulded integrally with the shell, is fitted to the nose of all tanks to increase erosion resistance.

The three-section design was chosen for ease of storage and quick assembly. Storage is simplified because the shells of several tanks can be put together to give a nesting ratio of about 3 to 1. The shell sections, and the detachable tail fin if used, are assembled by bolting simple mechanical joints. No glue is required, and the tanks can be assembled in the field by two or three unskilled men in about 10 or 15 minutes with simple tools.

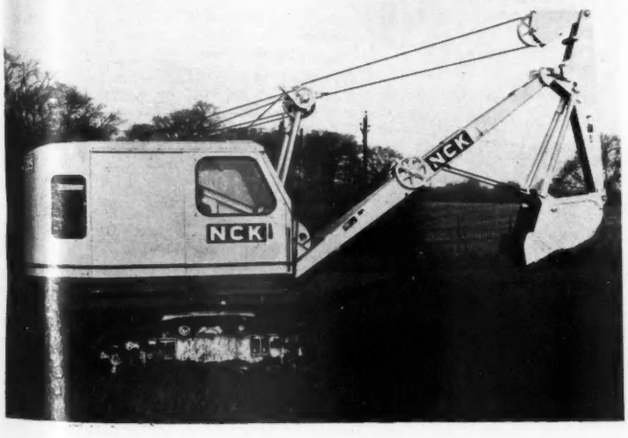
* * *

CONVERTING AN ELECTRIC SIGNAL TO CHANGES IN AIR PRESSURE

Unit for Automatic Control Systems

A converter unit for automatic control systems has been introduced by Elliott Brothers, Limited, Century Works, London, S.E.13, for use with thermocouples or similar low-potential direct-current sources. It is designed to give a linear change in air pressure for changes in the signal.

The converter comprises a chopper unit for converting the direct current to alternating, and this is then fed to a high-gain amplifier. This, in turn, operates an Eltair electro-pneumatic unit through a phase-sensitive rectifier. There are five input ranges, which can be quickly changed, and a stabilised direct-current supply which allows the introduction of cold junction compensation or a similar feature. The apparatus can be used as an input source for Elliott two- or three-term controllers or for temperature recordings.



The new Newton Chambers-Koehring 205 excavator can be equipped as a face shovel, drag shovel as shown here, skimmer, dragline, crane or crane-grab.

HANDLING OF OXIDANTS

FLEXIBLE TUBING FOR HIGH TEST HYDROGEN PEROXIDE

The properties of oxidants make them difficult and sometimes dangerous to handle, and now that oxidants are widely used in the propulsion of rocket motors, handling must be made as easy and safe as possible. One of the oxidants used is a solution of hydrogen peroxide concentrated to more than 75 per cent. by weight, which is known as high test hydrogen peroxide or H.T.P. The relative merits of H.T.P. and liquid oxygen as oxidants were discussed in an article entitled "Rocket Motor Oxidants" on page 78 of ENGINEERING, for January 21, 1955. Development of H.T.P. began before the last war, and during the war it was used in the propulsion of the German V2 rocket. Since the war much research work has been done both in this country and the United States of America on the use of H.T.P. as a propellant oxidant for submarines, torpedoes, guided missiles, and aircraft. Both the de Havilland "Sprite" and "Super-Sprite" rocket engines use H.T.P. When interplanetary flights are considered, H.T.P. has much to recommend it not only as a fuel, but because it carries within itself three of the four essentials for human life, water, oxygen, and heat.

In addition to being a concentrated and easily controllable source of energy, H.T.P. is a powerful oxidising agent. It is a highly concentrated source of active oxygen, and on decomposition by suitable catalysts will produce no additional substances other than water. The decomposition, or liberation of free oxygen, will happen if H.T.P. is heated, or it will occur violently at ordinary temperatures if brought into contact with a catalyst such as permanganate of potash. A less rapid decomposition can be brought about by various kinds of impurities, by the presence of certain metals and their salts, by alkalis and by many animal and vegetable tissues; the rate of decomposition is greatly increased by rises in temperature. H.T.P. is not inflammable, but is a strong supporter of combustion; in contact with dry wood or textiles enough heat may be generated by decomposition to cause spontaneous combustion.

The handling of H.T.P. presents several problems, and one particular problem has been to find suitable flexible tubing for conveying H.T.P. The Compoflex Company, Limited, 26 Grosvenor-gardens, London, S.W.1, claim to have solved the problem by producing a range of thin-walled flexible hoses, all entirely compatible with H.T.P. The hoses have been in operational use for two years, and have been approved by government departments. The basic materials are Terylene and a specially compounded P.V.C.; previous H.T.P. flexible hoses were made entirely of P.V.C., but they have not proved very satisfactory in service due to a lack of flexibility in cold weather, a liability to kink and collapse, and a relatively short life.

Two types of H.T.P. hose made by the Compoflex Company are in service, and a third is being developed. The first is a wire-supported hose for suction or delivery; it consists of a layer of specially compounded P.V.C. known as Molene, covered with a layer of Terylene which has been coated on both sides with the same P.V.C. mix. Over this is wound an austenitic stainless-steel wire helix covered with one layer of P.V.C. and two layers of P.V.C.-coated Terylene. The layers are then bonded together to give a light-weight, smooth-bore flexible hose. Sizes range from 1-in. to 3-in. internal diameter, and the properties of the 1½-in. internal diameter hose are: weight per foot 0·87 lb.; bend radius 4 in.; elongation ⅜ in. per foot at 200 lb. per square inch; test pressure 200 lb. per square inch.

The unsupported hose is of the collapsible, light-weight type which can be wound on a reel. A danger with collapsible hoses carrying H.T.P. is that small quantities of H.T.P. may be trapped and decompose. This was overcome by producing a sandwich-type hose, made of a layer of specially compounded P.V.C. between two layers of P.V.C.-coated Terylene. During manufacture a helical channel is formed in the bore lining, and this rifling prevents the build-up of gaseous products, because there is always an escape passage along the entire length no matter how the hose is kinked. The test pressure of the 1½-in. internal diameter hose of this type is 150 lb. per square inch, the weight per foot is 0·25 lb. and the elongation ¼ in. per foot at test pressure. The third type of hose is for use under higher pressures, and is still in the development stage. It is made from Molene and Terylene with helical wire support in much the same way as the medium-pressure hose, but it is covered with an overall braiding of stainless steel. The bead radius is actually increased by the addition of the braiding and the flexibility is claimed to be virtually unimpaired. A ¾-in. internal diameter hose, the first of the high-pressure range to be developed, is to have a working pressure of 800 lb. per square inch.

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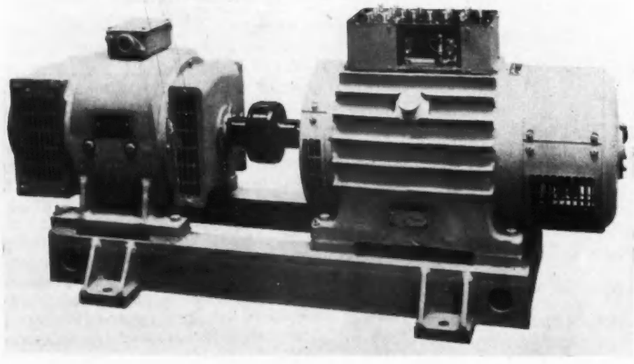
AMPLIDYNES FOR INSTRUCTIONAL PURPOSES

A new type of Amplidyne has been developed by the British Thomson-Houston Company, Limited, Rugby, for instructional purposes in universities and technical colleges. It is available in two frame sizes, each with two poles, one of which has an output of 0·8 kW at 220 volts and the other an output of 2·5 kW at 200 volts. The speed range of the first is from 1,410 to 1,500 r.p.m. and of the second from 1,430 to 1,500 r.p.m. An illustration of the latter machine is given below from which it will be seen that it is mounted on a common bedplate with its motor, which can be either of the alternating current or direct-current type, the drive being through a flexible coupling. The construction is generally the same as that of an industrial machine, except that a special terminal board, visible in the illustration, is provided in place of the normal terminal box.



2·5-kW 200-volt 1,430/1,500-r.p.m. two-pole Amplidyne designed by the British Thomson-Houston Company, Limited, for instructional purposes.

It will be recalled that the Amplidyne* is a cross-field direct-current generator with a quick response and a high ratio of output power to field power. It is used as an auxiliary exciter for equipments requiring accurate and automatic control, its many applications ranging from the remote position control of radar aerials to the automatic voltage regulation of turbo-alternators. To simulate this variety of work the fields of this machine have been designed so that they can be employed in a number of ways. All the leads from the windings and brush gear are brought out to separate terminals which are arranged in a diagrammatic layout on the board, while the normal connections are made by links. A tapping is provided in the compensating winding so that the operation of an under-compensated "constant-current" type of machine can be demonstrated and fine adjustment of the compensation over a small range can be effected by a diverter resistor.

* See ENGINEERING, vol. 162, page 103 (1946).

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LAUNCHES AND TRIAL TRIPS

M.S. "CERRO BOLIVAR."—Single-screw ore-carrying vessel, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, to the order of Joshua Hendy Corporation, Los Angeles, California, U.S.A., and transferred after delivery to Skibs A/S Vorma and Görrissen & Klaveness A/S, Oslo, Norway. Main dimensions: 549 ft. 4½ in. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,600 tons on a draught of 29 ft. 10 in.; ore-carrying capacity, about 377,000 cub. ft. Eriksbergs-B. and W. six-cylinder single-acting two-stroke Diesel engine, developing 7,500 i.h.p. Speed, 15¼ knots, fully loaded. Delivered, January 22.

M.S. "CRETIC."—Twin-screw cargo vessel, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Shaw Savill and Albion Co., Ltd., London, E.C.3. Main dimensions: 481 ft. between perpendiculars by 69 ft. by 33 ft. 4½ in. to upper deck; deadweight capacity, about 10,750 tons on a draught of 30 ft. 3 in.; gross tonnage, about 11,500; general-cargo capacity, about 340,000 cub. ft.; refrigerated-cargo capacity, about 300,000 cub. ft. Two Wallsend-Doxford six-cylinder opposed-piston reversible oil engines, together developing 12,860 b.h.p. at 114 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 17 knots. Launch, January 25.

M.S. "PATHFINDER."—Twin-screw pilot vessel, built by Philip and Son, Ltd., Dartmouth, for the Corporation of Trinity House, London, E.C.2. Main dimensions: 157 ft. between perpendiculars by 30 ft. by 14 ft.; mean draught 10 ft. 3 in. Two six-cylinder single-acting two-stroke Diesel engines, each developing 500 b.h.p. at 325 r.p.m. in service, constructed by British Polar Engines Ltd., Glasgow. Trial trip, January 25.

M.S. "CAPETAN CARRAS."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Tramp Chartering Corporation, Panama. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 40 ft. 4 in. to shelter deck; deadweight capacity, 13,320 tons on a draught of 30 ft. 7⅛ in. Swan Hunter-Doxford five-cylinder oil engine, arranged to burn boiler fuel and developing 5,500 b.h.p. at 115 r.p.m. in service. Speed on trial, 15½ knots. Trial trip, January 26.

M.S. "BOSTON MONARCH."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for St. Andrew's Steam Fishing Co., Ltd., Fleetwood. Main dimensions: 137 ft. 6 in. between perpendiculars by 28 ft. by 13 ft. 9 in.; gross tonnage, 420. Six-cylinder direct-reversing Diesel engine, constructed by British Polar Engines Ltd., Glasgow, and installed by the Drypool Engineering and Dry Dock Co., Ltd., Hull. Launch, January 27.

OVERCOMING FREQUENCY VARIATIONS

OUTPUT ACCURATE TO WITHIN 0·1 PER CENT.

For many laboratory and industrial processes the frequency variations of the public supply mains are more than can be tolerated, especially in the more remote places abroad which may have Diesel generating sets or power stations without frequency control. Frequency variations, even in this country, are more than can be tolerated for the supervisory equipment of certain chemical and metallurgical processes, of radar and gyro apparatus, and for the operation of telegraph instruments by synchronous motors. To give an accurate frequency supply Walter Jones and Company (Engineers), Limited, Newlands Park, London, S.E.26, have designed and developed the motor-alternator set shown in the accompanying illustrations.

The set consists of a motor which drives an alternator through a variable-ratio gear; the ratio of the gear is varied by a differential speed comparator, which is described in detail below. The motor is designed to deliver its full load under the extreme conditions of frequency and voltage variation of the available supply. The alternator is designed to give the required frequency, say 50, 60 or 400 cycles per second; it is either self-regulating or has a separate exciter and automatic voltage regulator. The variable-ratio gear which couples the motor and the alternator is controlled so that it will slow the alternator down if the output frequency rises, and speed it up if the output frequency falls.

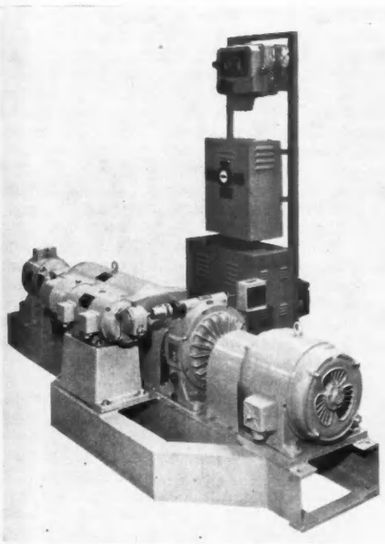

Fig. 1 The output frequency from this motor-alternator set is kept accurate to within 0·1 per cent. The alternator is coupled to the motor by a variable-ratio gear, which is controlled by a differential speed comparator.

The differential speed comparator consists of three parts: a self-excited alternating-current synchronous motor (the slave motor), which rotates in step with the generated frequency of the main alternator; a constant-speed standard; and a differential gear which compares the two rotations. The speed standard is a direct-current governed motor which operates from a rectified alternating-current supply. The governor controlling the standard-speed motor was described in ENGINEERING of June 13, 1952 (vol. 173, page 763); as will be clear, it is the mechanism on which the accuracy of the whole set depends. It consists basically of a cantilever spring which has a very low coefficient of elasticity variation with temperature; it operates in a manner analogous to the Tirrill voltage regulator, that is, it controls the mean field strength by short-circuiting a resistance in the shunt circuit. This short-circuiting takes place for a varying period during each revolution, depending on the variation of the speed from standard. The governor is claimed to hold the speed accurate to one part in a thousand for very long periods without attention. The available output from the two motors, the speed standard and the slave motor, is such that the excess torque when they are running at different speeds is sufficient to operate the ratio-changing shaft of the variable-ratio gear through a worm reduction gear. The set illustrated in Fig. 1 shows the differential speed comparator on the left-hand side, and the output shaft connected to the variable-ratio gear can also be seen. In Fig. 2, the side of the differential comparator is cut away. At the left-hand end inside the casing can be seen the governor; next to it is the standard speed direct-current motor; between the slave motor and the standard speed motor is the differential gearing; the shaft transmitting the output to the variable-ratio gear control can be seen passing through the centre of the slave motor.

In steady-state operation of the plant the slave motor and the standard-speed motor rotate at the same speed. The speed of response to transient conditions is such that the output frequency can be corrected for rates of change of input frequency much more rapid than are likely to occur in practice. The set compensates for an input frequency change of up to one cycle per second with a 50-cycle supply, which is more than double the most rapid rate of frequency change normally encountered. The second transient condition to be considered is that resulting from sudden load changes. When the driving motor is of the induction type, a sudden change of load causes a corresponding change in slip, which has to be corrected by the automatic correction equipment. Complete correction takes about 20 seconds, but about 80 per cent. of the correction is effected in 10 seconds. The use of induction-motor drives is restricted to cases where the sudden load changes are not more than about 15 per cent. of the output power. In cases where a large proportion of the output power has to be switched on and off, synchronous induction motor drives are used, and the automatic frequency control has then to correct for input frequency errors only.

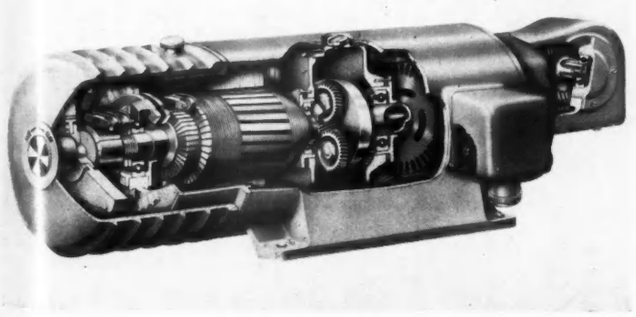

Fig. 2 Differential speed comparator with side cut away showing, from left: governor, standard speed motor, differential gear, slave motor, and drive to ratio-adjusting shaft of variable-ratio gear.

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ADJUSTABLE OPERATING PLATFORM

Donald Ross and Partners, Limited, 1-3 Arlington-road, London, N.W.1, have designed an adjustable operating platform called the Twinner hydraulic operators' platform. The main purpose of the platform is to make welding on large boiler shells quicker and safer, but it can be used for many other purposes.

The platform, shown in the accompanying illustration, has a latticed base which is mounted on two fixed front wheels and two castors at the back to make it easy to steer into position. Two jacking screws at the rear of the base can be adjusted to ensure stable four-point mounting on the floor, and to prevent coasting on surfaces which are not level. A hand-operated hydraulic pump immersed in a sealed tank of hydraulic fluid is also mounted at the rear of the base. From the pump, hoses lead to two 30 in. stroke hydraulic jacks pivoted at the bottom of the tower and pivotally connected to the lower links of the platform. The platform brackets form the upper end links of a parallelogram linkage; the platform thus remains level at all heights.

12 ft. 4 in. is the greatest height from the ground to which the platform can be raised.

The platform has a forward reach which allows the operator to work over the centre of a drum 10 ft. in diameter; it can be adjusted to any height between 5 ft. 2 in. and 12 ft. 4 in. from floor level. The platform measures 4 ft. 6 in. by 2 ft. 3 in. and is floored with ¾ in. wooden boards; it has a safe working load of 4 cwt. in any position, and there are steps on the tower for climbing on to the platform. Total weight of the assembly is approximately 700 lb.

Fig. 1 The alternating-current winding motor installed at Avon Colliery has a speed control system closely approaching the range of the Ward Leonard system, in addition to dynamic braking.

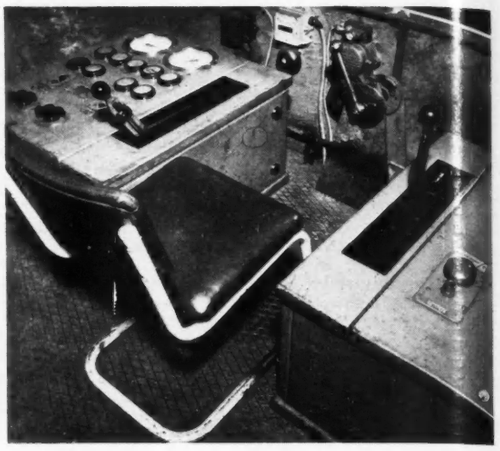

Fig. 2 The main winding control lever, covering forward, reverse, and speed control, is on the driver's right. Further to his right is the emergency stop button.

ELECTRIC WINDER WITH SPEED CONTROL

ALTERNATING CURRENT EQUIPMENT INSTALLED AT AVON COLLIERY

For the modernisation of the winding plant at Avon Colliery, Blaengwynfi, South Wales, the General Electric Company, Limited, was commissioned to supply and instal a complete electrically-driven winding engine to replace the existing steam engine. The contract covered a 1,100-h.p., 3·3-kV, 475-r.p.m. slipring motor with its associated control gear, and the supply of a new parallel winder drum, 12 ft. in diameter by 8 ft. wide, which was built at the Company's Erith works. The installation is shown in Fig. 1, above.

With a depth of wind of 1,575 ft., the plant is designed to raise approximately 3 tons of coal or 5½ tons of stone per wind, the winding cycle being:—Acceleration, 10 sec., full speed, 36·3 sec., deceleration, 10 sec., decking, 20 sec. This represents about 47 winds per hour, giving an hourly output of some 140 tons of coal. The installation is of particular interest since it is the first alternating-current winder in this country to use the new G.E.C. system of dynamic braking and speed control, the operation of which, as far as the driver is concerned, approaches closely that for direct current equipments using Ward Leonard control with overriding current limitation.

The changeover was carried out during the holiday fortnight, the work having been planned beforehand by the use of a model. Owing to the difficult access at the Colliery, all the components for the new plant were placed on trolleys in the order in which they would be required. Similarly, trolleys were used to remove the parts of the original installation. The work was completed, and the machinery checked, in time for the first shift after the holiday break.

DYNAMIC BRAKING AND SPEED CONTROL

The new G.E.C. dynamic braking and control system with speed control features is a further development of a similar scheme installed for four 4,200-h.p. alternating-current winders in the Orange Free State Goldfields, the first two of which were commissioned some three years ago. The system there was designed to give accurate torque control and the subsequent performance of these winders has fully substantiated the claims made. With the additional feature of speed control which is embodied in the new scheme, a direct relationship is afforded between the steady rope speed and the position of the driver's lever.

Referring to Fig. 3, automatic variation of the rotor circuit resistance of the winder motor is effected through the medium of an oil servo mechanism, the operating valve of which is governed by two control coils, acting in opposition to each other. Coil LR, which causes the resistance in the rotor circuit to be reduced, is energised by an alternating current. When driving, this current varies with the difference between the desired and the actual speed. During dynamic braking, this current is constant.

The other coil, RR, which serves to insert resistance, is excited from the stator or secondary winding of a control generator driven from the winder motor. At any given rotor, or primary, excitation of the control generator, the voltage across this coil reflects that of the rotor of the main winder motor and varies in proportion to the slip or speed. The actual proportion is dependent upon the speed error.

The operation can be followed from the schematic diagram, Fig. 3, by considering the sequence of events following three typical quick motions of the driver's lever. The arrangement of the controls is shown in Fig. 2.

"*Stop*" *to* "*Half-Speed Forward.*"—Movement of the driver's lever through the gate immediately sets up control circuits for the "forward" direction. Further movement to the half-speed forward position causes the pattern potentiometer, PP, to apply half of its maximum voltage to the speed error signalling loop, TG-MA1-PR circuit. The current saturates the amplifier MA1 which produces its maximum output. At the same time the polarised relay PR closes contacts which set up the main contactor circuits for "driving."

With any speed error in excess of a predetermined value, the magnetic amplifier MA1 delivers its maximum output to the control windings of the biased saturable reactors SR1 and SR2 by way of the forward or reverse contactors F and R. As the control winding opposes the bias winding of SR1, this reactor then gives minimum output and hence minimum excitation of the control generator, CG. The excitation and consequently the pull of coil RR is, therefore, at its minimum.

On the other hand, as the control winding assists the bias winding of the saturable reactor SR2, the output from this reactor produces maximum excitation of the coil LR of the oil servo-mechanism. Thus the pull of coil LR is able to overcome that of coil RR and reduce the resistance of R1 and of the liquid controller R to the required values for the winder motor WM to accelerate at the chosen maximum torque. As the motor gathers speed the voltage of the tacho-generator, TG, rises. Since this voltage opposes the pattern voltage, the current in the speed balancing winding of the amplifier MA1 falls; no change takes place, however, in the output from this amplifier because it is so designed that it remains saturated so long as the difference between the tacho-generator voltage and the pattern voltage is large.

Acceleration continues, therefore, at maximum torque until the actual speed approaches the selected speed, when the output of the amplifier MA1 falls. This results in a rapid rise in the

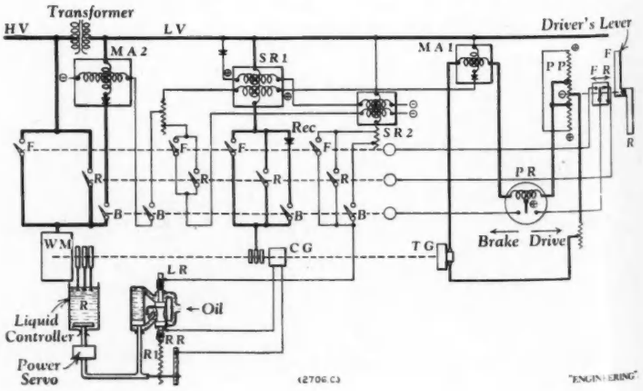

Fig. 3 Circuit diagram of the system.

output voltage of the biased saturable reactor SR1 and thereby causes the excitation of CG to increase. Thus coil RR takes control and raises the resistance of R1 and R until the torque of the winder motor equals the load torque. When this occurs, the speed no longer increases.

As the wind proceeds, the down-going load increases with the length of rope and may ultimately exceed the up-going load. In this event the speed will rise. When it exceeds that set by the driver's lever, the tacho-generator voltage will exceed the voltage derived from PP, and the current in the speed balancing winding of MA1 and in PR will be reversed. The reversal of current in the speed balancing winding has no effect, because the amplifier MA1 is non-directional and gives the same output for the given control current in either direction. The polarised relay PR, however, changes over its contacts thus opening the main driving contactors and closing the braking contactors.

As a result, the output from the amplifier MA1 feeds the saturable reactor SR1 and the magnetic amplifier MA2, while SR2 receives constant excitation. MA2 now supplies an increasing direct current excitation to the stator of the winder motor WM until the braking effort is sufficient to balance the down-going load. During dynamic braking the reactor SR1 supplies direct current excitation through the rectifier REC to the control generator CG. The relationship between the excitation of the winder motor and that of the control generator is so chosen that the resistance R is automatically kept at its optimum value, independently of the motor speed.

When the cage enters the retarding zone, the driver's lever is moved back to reduce speed. The tacho-generator voltage then exceeds the pattern voltage and braking excitation (limited by the amplifier characteristics) is applied. Maximum braking torque is developed upon any rapid backward movement of the driver's lever. On reaching bank, full application of the mechanical brakes opens the dynamic braking contactor.

"*Stop*" *to* "*Full Speed Forward.*"—Acceleration to full speed takes place at maximum torque, as already described. Assuming that the wind is such that regenerative braking is possible, this will begin on a slight rise in speed above synchronism, the pattern potentiometer PP being set to permit the necessary increase without changing over to dynamic braking. On entering the retarding zone a backward movement of the driver's lever will cause the polarised relay PR to change over and initiate dynamic braking.

"*Full Speed Forward*" *to* "*Full Speed Reverse.*"—The first movement of the driver's lever from "forward" towards "stop" will of course initiate dynamic braking, since the pattern speed will be less than the actual speed. When the lever passes through "stop" towards "reverse," the pattern voltage increases once more in the same direction but, as the field of the tacho-generator TG is reversed, the pattern and tacho-generator voltages are now additive. The polarised relay PR, therefore, restores the "driving" circuits, and reverse-current braking is applied at maximum torque and under optimum conditions.

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INCREASE IN FEES FOR PATENTS AND DESIGNS

The Board of Trade have announced that as from February 1, higher renewal fees are being charged for patents and designs registrations due to expire after April 30. As from May 1 there will be a general increase in the fees payable in respect of a number of patents and designs matters. It is pointed out that these fees have remained substantially unchanged for many years despite considerable increases in administrative costs. Revised Rules amending those made under the Patents Act, 1949, and the Registered Designs Act, 1949, have been laid before Parliament. The Patents Rules have been amended in minor respects to make them conform to the requirements of the European Convention of December 11, 1953.

OLYMPUS JET ENGINE TYPE-TESTED

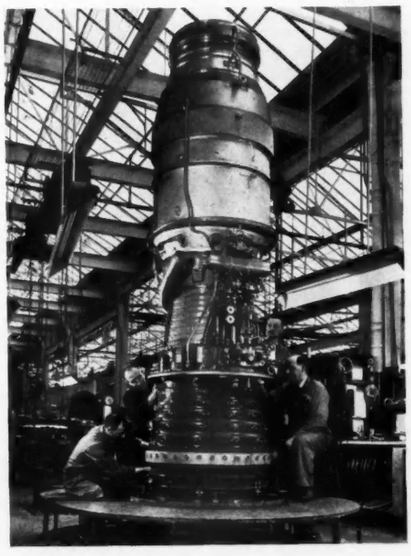
11,000 lb. Thrust Developed

After successfully completing a 150-hour type test including 5 hours at take-off power, 87½ hours at cruising conditions, 10 hours of running alternating between ground-idling and take-off, and a short period of overspeed running, the Olympus 101 turbo-jet has been officially approved by the Ministry of Supply for service at 11,000 lb. thrust without after-burning. Now in quantity production at the works of the Bristol Aeroplane Company, Limited, Filton, Bristol, the Olympus 101 is to be installed in production Avro Vulcan delta-wing bomber aircraft for the Royal Air Force.

The Olympus, it may be recalled, is a "two-spool" engine designed for low fuel consumption over a wide range of altitudes. By using a low-pressure compressor to supercharge a high-pressure compressor, coaxially mounted, each being driven by an independent turbine with no mechanical interconnection between the two systems, it is possible to work at a high compression ratio—each compressor running at its optimum speed—without sacrificing flexibility of performance. At a press demonstration recently, the ability of the Olympus 101 to respond instantaneously to opening up the throttles after closing them right down was demonstrated in flight in the company's Canberra flying test-bed—the same aircraft which, with two less powerful Olympus engines installed, established a world altitude record of 63,668 ft. in 1953.

HYDRAULICALLY-OPERATED ASSEMBLY FIXTURE

The accompanying illustration shows the final stages of assembly of an Olympus 101 engine, on a hydraulically-operated assembly fixture which allows the engine to be raised or lowered so that the fitters are able to work comfortably at ground level. As shown, the intake casing is at the bottom and the tail cone is at the top. An electrical generator housed in the air intake is not visible in this view. Information on the construction of the Olympus is still restricted, but it has been stated that the low-pressure compressor assembly and casing are in aluminium alloy, whereas the high-pressure assembly is in stainless steel.



Assembly of the Olympus 101 turbo-jet, now in production, is carried out on a hydraulically-operated adjustable assembly fixture enabling the fitters always to work at ground level. The engine, in the final stages of assembly, is shown raised to its full height.

At 11,000 lb. thrust, the engine has a specific fuel consumption of 0·79 lb. per pound thrust per hour—claimed to be about 10 per cent. better than that of a single-spool engine at the same design condition. The weight of the engine is 3,650 lb., giving a specific weight of 0·33 lb. per pound thrust. While this figure is higher than that of the latest single-spool engines, the Bristol company point out that the Olympus 101 is in fact a "1950-vintage" engine, and they expect to achieve in further-developed versions a specific weight lower than that of corresponding single-spool engines. In any case the altitude performance of the twin-spool engine is sufficiently in advance of the single-spool type to compensate for a heavier installation weight.

Although designed in the first place for long-range applications, the chief engineer of the Bristol Engine Division, Dr. S. G. Hooker, has stated that in his view the two-spool jet engine is well suited as a power plant for supersonic aircraft since it can operate over a wide range of intake conditions. Such an engine would be designed to give a lower pressure ratio than that of the Olympus.

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"SUPER SPRITE" ROCKET MOTOR

Approved for Service

The de Havilland Engine Company, Limited, Stag Lane, Edgware, have announced that the Super Sprite rocket motor has passed the Ministry of Supply type test and thus becomes the first British rocket motor approved for quantitity production and general service use.

The Super Sprite employs hydrogen peroxide in conjunction with a solid metal catalyst, which causes dissociation into steam and oxygen, and its thrust is augmented by the after-burning of kerosine or petrol. The motor, which has a dry weight of 620 lb., gives a total impulse of 120,000 lb.-sec. with a maximum thrust of 4,200 lb. and a duration of 40 seconds.

The Super Sprite is intended mainly for assisting the take-off of jet bombers or similar aircraft. It may be employed as a fixed installation or may be jettisoned by parachute after take-off.

No information is available on later de Havilland rocket developments, but it is known that their work is not confined to assisted take-off applications.

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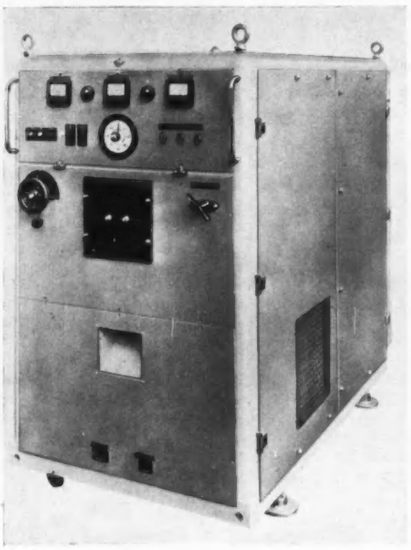
BEVERLEY TRANSPORT AIRCRAFT

First Production Machine Flies

The first of the 60-ton Beverley transport aircraft to come off the production line at the factory of Blackburn and General Aircraft Limited, Brough, East Yorkshire, has recently made a satisfactory maiden flight. The Beverley, which is to go into service with the Royal Air Force, is designed to carry large and heavy military equipment, with a cargo compartment measuring 40 ft. by 10 ft. by 10 ft. and a maximum payload of 50,000 lb. In addition to the cargo compartment, there is accommodation in the tail boom for 36 troops or additional cargo.

An impressive feature of the Beverley, which is powered by four 2,850-h.p. Bristol Centaurus engines, is its ability to operate from unprepared grounds of comparatively small dimensions; at full load the take off run is 790 yards and the landing run 310 yards. The normal range over which the aircraft is likely to be flown is about 1,600 miles with a payload of 30,000 lb., at the recommended cruising speed of 175 m.p.h. The maximum cruising speed is 223 m.p.h., and the maximum level speed 238 m.p.h. The wing span is 162 ft. and the length of the body 99 ft.



Supplying 12 kW at continuous rating, this high-frequency generator can be used with a built-on work table or can supply benches at some distance.

INDUCTION HEATER

High-Frequency Generator for General Work

A high-frequency generator for induction heating which can be used for a wide range of processes has been produced by E.M.I. Factories, Limited, Hayes, Middlesex. It is a completely self-contained unit, having a built-in cooling system, and can be used to supply a local work station or to feed a remote one by a transmission line. The generator is rated at 12 kW for continuous operation into a load of high power factor, or 14 kW if a 50 per cent. duty cycle is employed. When feeding into a load with a low power factor the ratings are given as 500 kVA and 700 kVA respectively.

A series of work-matching capacitors is incorporated in the generator which can be used in various combinations giving up to 0·14 mF., but when a long transmission line is used the capacitors can be omitted. The output coupling system is continuously variable and is suitable for feeding into a coaxial line; a dual range ammeter on the control panel facilitates matching to a transmission or external work circuit. The output voltage is controlled by a hand wheel on the panel. For controlling the duration of operations, a timing unit is included. This has a standard range from 0 to 30 seconds, but ranges of 0 to 10 seconds and 0 to 4 hours can also be fitted. The set is arranged to operate from a 3-phase, 50-cycle supply.

A motor-driven centrifugal air blower and a water pump supply the cooling for the generator. The water reservoir contains sufficient to obviate the need of an external supply, the circulated water being cooled by a car type radiator block. The welded-steel case is mounted on double castors and has four built-in jacks to take the weight when it has been sited. Four eye bolts can be screwed into the top corners for lifting or into the bottom corners for hauling.

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An oscillograph tube has been introduced by Electronic Tubes, Limited, Kingsmead Works, High Wycombe, Buckinghamshire, which incorporates post-deflection acceleration and which is particularly suitable for high-frequency work and high writing speeds. Post-deflection acceleration combines good brightness with high deflection sensitivity and enables waveforms of small amplitude to be studied with a minimum of amplification.

NEW WELDING SHOP AT ACTON RAILWAY WORKS

Equipment for Steel and Non-Ferrous Materials

A new arc welding shop has been established at the Central Overhaul Works of London Transport's railways at Acton to deal with the increasing proportion of fabricated components employed in the maintenance of electric rolling stock. Both alternating and direct-current equipment has been installed, the former being normally used to produce steel structural components and the latter for cutting or welding non-ferrous metals.

A view of the new shop is given in Fig. 1, from which it will be seen that two parallel rows of welding booths are provided. A rectangular space between these rows affords access to the equipment and storage space for the work in progress. One row consists of four booths in which direct-current welding is carried out, the necessary current being supplied by two double-operator generators. The six booths in the other row are employed for alternating-current welding.

Both sets of booths contain a wheeled table which is held in the welding position by a foot-operated latch, as is to be seen from Fig. 2. On the right is a regulator which is capable of handling welding currents up to the maximum values and is connected to the distributor cable and electrode holder through plugs and sockets, as can also be seen in Fig. 2. The half doors in the front of each booth are in three sections, that in the centre being used for access and for small work, and the other two for admitting larger equipment. This equipment is handled by a two-ton overhead crane constructed by the Wharton Crane and Hoist Company, Limited, Reddish, and provided with floor-operated controls. A power supply to all six alternating-current booths is obtained from a six-operator welding transformer of English Electric manufacture, the maximum rating of which is 300 amperes per operator. This transformer is mounted on an overhead gantry and each phase supplies an adjoining pair of booths through cables which are carried in a longitudinal steel duct. It is possible, by working in parallel, to use currents up to 600 amperes.

The fumes produced by the welding and cutting processes are withdrawn through a duct over each row of booths. One end of these ducts is connected through openings of pre-set dimensions to canopies covering the rear of each booth, and the other to electrically driven fans which exhaust the fumes to the outside of the building.

As the new shop is situated at one end of a bay served by two cabin-controlled overhead cranes, the crane drivers' eyes are protected from flash from the welding booths by a narrow screen. This extends the full length of one side of the shop with a diagonal section across the end, as can be seen in Fig. 1. While affording the necessary protection, this leaves the central area of the shop visible to the drivers. The cranes can therefore be used, when necessary, for loads above the capacity of the local 2-ton crane.

Fig. 2 A typical booth showing the wheeled table in the welding position, the welding regulator on the right, the outlet socket at the rear and the fume exhaust canopy above.

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ELECTRONICS DISPLAY CENTRE

As one of the organisations that have made a major contribution to the development of electronics in this country, Mullard Limited have spared no effort to encourage the dissemination of information on this wide subject. In pursuance of this policy they have recently opened a permanent centre for the display of their products and the provision of information at their publicity offices, 1 Gerrard-place, Shaftesbury-avenue, London, W.C.2. On the first floor examples from each group of the Company's products are arranged in panels which can be separately illuminated and wall maps show the ramifications of the firm's business in this country and overseas; their current literature is also displayed and is available to visitors. On the lower floor, panels illustrate how Mullard products are made and used and on this floor larger exhibits will be housed and arranged for special exhibitions and demonstrations.

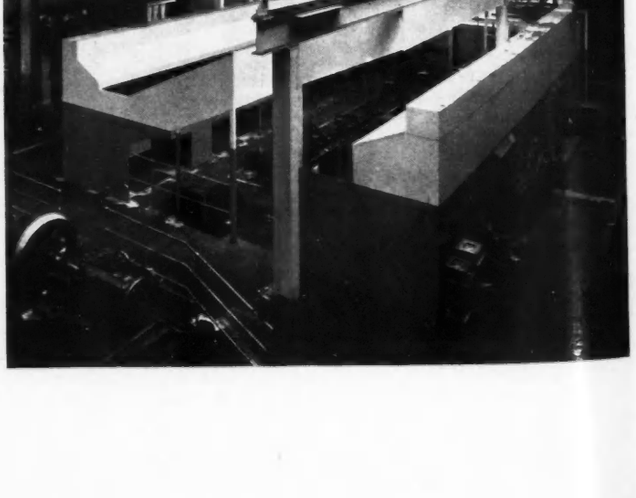
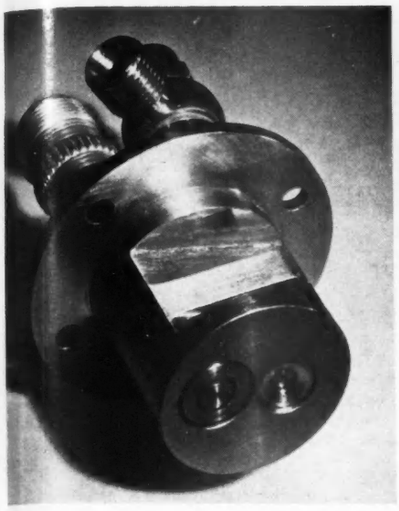


Fig. 1 View of the new welding shop at the Acton works of London Transport from the cabin of one of the overhead cranes, showing the screen which protects the drivers' eyes.



The K.L.G. high-energy torch igniter was designed initially for the de Havilland Ghost engine, using the Dowty spill-burner fuel system. It provides an auxiliary fuel spray from a fuel nozzle only ½ in. from the igniter electrode.

TORCH IGNITER FOR GAS TURBINES

Auxiliary Spray Facilitates Starting

A new design of high-energy torch igniter has been developed by K.L.G. Sparking Plugs, Limited, Putney Vale, London, S.W.15, an associate company of Smiths Aircraft Instruments, Limited, Cricklewood, London, N.W.2, who are their sole sales agents. Produced initially for the de Havilland Ghost engine, this new type of igniter can be applied to other gas turbine engines. It has been developed for use with the Dowty spill-burner fuel system.

Igniters are used during the engine-starting cycle and for relighting the engine in the air. Normally they consist of an ignition plug, the spark of which touches off the edge of the fuel spray from the main burner. Sometimes, through a combination of circumstances, the fuel is not ignited quickly, which may cause on the ground a " wet " start or in the air difficulty in relighting.

Without altering the overall dimensions of its present igniter adapter—which is bolted to the combustion-chamber outer can and carries the igniter into the inner flame tube—K.L.G., in conjunction with the de Havilland Engine Company, have redesigned the unit so that alongside the igniter is a fuel atomiser. The centre of the fuel nozzle for this auxiliary spray is only ½ in. from the high-energy igniter electrode. During the starting cycle, fuel from the auxiliary spray ignites in a ball of flame which projects well down into the main fuel stream.

In spite of its advantages the height of the new igniter above the outer can is little greater than that of the previous installation.

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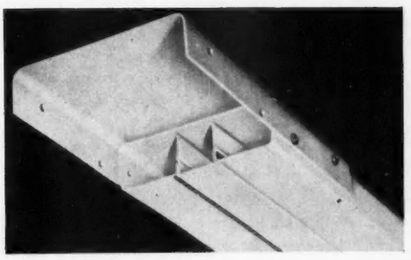
SHALLOW TRUNKING FOR LIGHTING CIRCUITS

The Edison-Swan Electric Company, Limited, 155 Charing Cross-road, London, W.C.2, have introduced a form of trunking for lighting circuits which is shallow in depth and can be used with standard conduit fittings. The trunking is 4½ in. wide by 1½ in. deep. It can be supplied in Bonderised enamelled 18-s.w.g. steel, or in extruded aluminium, 0·1 in. thick.

The illustration shows a length of trunking



Shallow trunking for lighting circuits, in which a U-shaped sealing strip divides the trunking into three ducts. A carrier plate will accommodate standard conduit fittings.

with a junction plate; the U-shaped sealing strip, which divides the interior into three ducts, is shown sprung into place. Fittings are attached by a carrier plate which takes the place of the sealing strip and has an entry for ¾ in. conduit. The plate is held in position by two screws which bear against the top of the trunking and ensure earth continuity. It is suggested that principal circuits should be run in the outer ducts and the connections linking the fittings in the middle one. End caps for terminating the trunking have three knock-out plugs for conduit.

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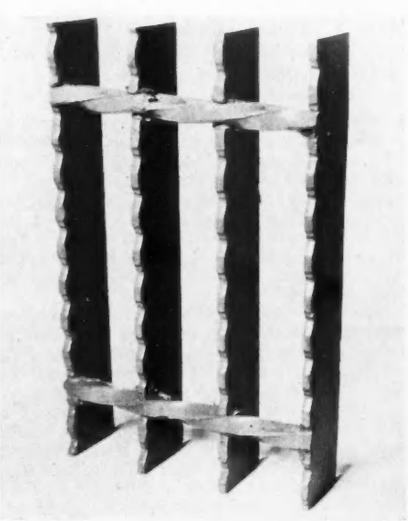
STEEL FLOOR GRATING

There are many occasions when it may be necessary or advisable for a flooring to be made of a grating. This may be either on account of wet working conditions or where air is required to circulate freely, or it may be merely that it is a cheap and convenient form of construction. Many different types are in use, and one, particularly designed for areas where walking conditions are hazardous, is now being made by the grating department of the Blaw-Knox Company, Farmers Bank Building, Pittsburgh, Pa., U.S.A. A section of this grating is shown in the illustration below. Manufactured from forged steel, the bearing bars have mill-rolled serrated edges which are claimed to give a good traction surface with comfortable walking conditions. The cross bars are of twisted steel driven through the bearers, as may be seen from the illustration. The grating is available in various sizes with bearer bars $\frac{3}{16}$ in. wide and from 1 in. to 2 in. deep.



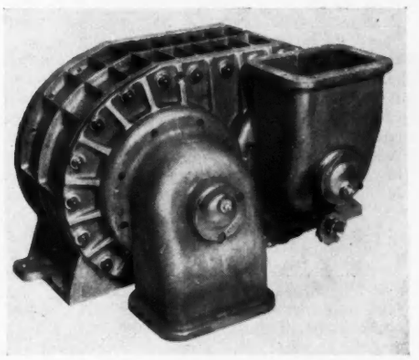
A steel floor grating with mill-rolled serrated edges to give a safe walking surface.

IMPROVED COMPRESSOR

Report of Tests on Second BICERA Model

In a report issued recently (No. 54/6P) the British Internal Combustion Engine Research Association, 111-112 Buckingham-avenue, Slough, Buckinghamshire, state that, following trials on the second model of their compressor, they consider it to have reached a stage suitable for commercial development. This second model is somewhat larger than the prototype, and is designed to work between 5 and 20 lb. per square inch gauge. An exterior view is given in the illustration below.

The second model is made of aluminium alloy wherever possible, and weighs 189 lb. Overall dimensions, including the elbow ducts, are 15⅝ in. by 20½ in. by 12¾ in., the swept volume being 0·242 cub. ft. per revolution. As distinct from the prototype, the rotors of the second model have bearings at each end; this has enabled smaller bearing sizes to be used and has allowed the main roller race to be brought into the rotor bore, which both saves space and increases rigidity. The outer bearings are built into the



The second model of the BICERA compressor is made largely of aluminium alloy. Peak adiabatic efficiencies of 77 per cent. have been obtained.

ducting. The port edges have been modified to improve the air flow and this has had an appreciable effect on the efficiency. The inlet valve was fitted with a variable timing sleeve.

Tests on the compressor have given overall adiabatic efficiencies of 60 per cent. at 20 lb. per square inch, 65 per cent. between 9 and 17 lb. per square inch and 73 per cent. between 2·5 and 9 lb. per square inch. The peak value reached under test was 77 per cent. Using the inlet valve to reduce the throughput of the compressor (to simulate an engine running at light load) showed that the driving power could be reduced from 44 h.p. to 12 h.p., which would represent a considerable saving in fuel consumption. In addition to the compression tests, the machine was tried as an exhauster. The performance proved to be slightly better than at the corresponding pressure ratios when used as a compressor. Depressions as low as 20 in. of mercury were obtained, but improved oil seals would be needed for continuous operation at this figure.

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GLASS FIBRE LAMINATES

An addition to the glass-fibre laminates now available is a range called " Rilglaze," manufactured by Rubber Improvement, Limited, Wellingborough, Northamptonshire. These laminates consist of a polyester resin base reinforced with glass fibres, and possess the high mechanical strength and good insulation properties of glass reinforced plastics.

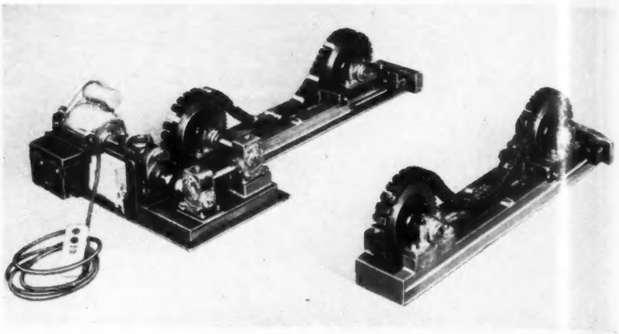
SPEECH RECORDER FOR THE POCKET

Battery-operated Instrument Gives 2½ Hours Recording Time

Now being distributed in this country by the Emidicta division of E.M.I. Sales and Service, Limited, 363-367 Oxford-street, London, W.1, the "Minifon" magnetic pocket recorder is made by Protona of Hanover, Western Germany. The recorder measures 1⅝ in. by 4⅜ in. by 6⅝ in. and weighs 2½ lb. complete with batteries and recording wire. The spool can accommodate enough wire for 2½ hours recording and the frequency response is from 200 to 4,000 cycles per second.

The driving motor is supplied from a 12-volt dry battery which has a life of about 10 to 15 hours. Alternatively, a mercury battery can be used, the life of which is 33 hours. When it is convenient to do so, the supply can be taken from the mains through a transformer and rectifier unit; plugging this into the set automatically disconnects the internal battery. A 30-volt and a 1·4-volt battery supply the three-valve amplifier. The motor is controlled by an on-off switch at one end of the case and there is a reversing switch for re-winding at the side. A contact-type governor controls the running speed by cutting out the motor when it goes too fast. The drive to the winding spool, which is heavy and acts as a flywheel, is through a spring belt which also serves the purpose of a slipping clutch when the end of the recording wire is reached in either direction. When the re-wind is started, the spool is automatically stopped by a friction pad and then released, its subsequent motion being checked by a second pad in order to prevent over-run. During both forward and re-wind running, the recording head moves to and fro in order to guide the wire on to the spools in even layers. The erasing magnet is swung into and out of position by a pin which projects through the case.

For recording, a standard lapel or table microphone is used. This can pick up normal speech at a range up to about 20 ft. The lead plugs into the set near the on-off switch. Alternatively, throat or wrist microphones can be used of a telephone pick-up if required. Playback can be either through head-phones or a radio loud-speaker; in either case the leads plug into the same socket in place of the microphone, the plug making the correct contacts. An adjustable volume control operates for both recording and playback. If it is desired to make typescript transcriptions at an office desk, a foot control unit can be fitted which operates both forward and re-wind running, leaving both hands free for typing. A new spool of wire can be fitted in a matter of moments and a recording can be stored indefinitely. The recorder is supplied in a leather case with a shoulder strap.



In the pipe-welding rig rubber-shod chains act as slings for the workpiece, and adapt themselves to its shape, ensuring that good contact is maintained at all times even if the workpiece is not truly cylindrical.

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PIPE-WELDING RIG

A rig for positioning light-weight pipes and drums for welding or oxy-acetylene cutting has been developed by Donald Ross and Partners, Limited, 1-3 Arlington-road, London, N.W.1. Known as Twinner Junior Trac Treds, it is claimed that the new rig eliminates completely the disadvantages of the normal roller-type rig in which, if the cylinders are not truly concentric, there is a loss of traction owing to the uneven load distribution, and the workpiece tends to corkscrew from its correct rotating position.

The Trac Tred rig, available in 1-ton and 2-ton capacities, is shown, with guards removed, in the accompanying illustration. It consists of two specially designed rubber-shod chains which act as slings for the workpiece. The chains are flexible and shape themselves to the contour of the cylinder, thus ensuring that a large area of the cylinder is in contact at all times. The chains will support the thinnest shell without indentation.

A standard power unit is fitted to one of the chains, the second chain acting as an idler. The power unit has a 6-to-1 infinitely variable speed giving a track speed range of 8 in. to 48 in. per minute. The equipment can be remotely controlled from a trailing cable and switch, as illustrated.

A simple screw adjustment on one sprocket adjusts the loop on the chain to suit the diameter of the loaded cylinder. A steel backing plate is interposed between the rubber shoes so that damaged shoes are easily replaced.

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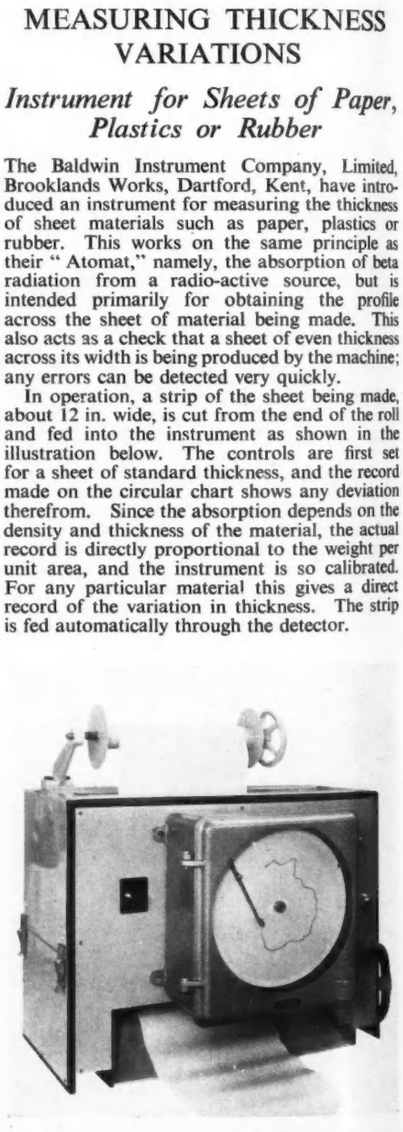
MEASURING THICKNESS VARIATIONS

Instrument for Sheets of Paper, Plastics or Rubber

The Baldwin Instrument Company, Limited, Brooklands Works, Dartford, Kent, have introduced an instrument for measuring the thickness of sheet materials such as paper, plastics or rubber. This works on the same principle as their "Atomat," namely, the absorption of beta radiation from a radio-active source, but is intended primarily for obtaining the profile across the sheet of material being made. This also acts as a check that a sheet of even thickness across its width is being produced by the machine; any errors can be detected very quickly.

In operation, a strip of the sheet being made, about 12 in. wide, is cut from the end of the roll and fed into the instrument as shown in the illustration below. The controls are first set for a sheet of standard thickness, and the record made on the circular chart shows any deviation therefrom. Since the absorption depends on the density and thickness of the material, the actual record is directly proportional to the weight per unit area, and the instrument is so calibrated. For any particular material this gives a direct record of the variation in thickness. The strip is fed automatically through the detector.



The Atomat instrument for thickness measurement utilises the absorption of beta-rays.

LONG PRESTRESSED CONCRETE STRUCTURES

Bridges in United States and Asia

Information has recently been received concerning two exceptionally long bridges constructed of prestressed concrete, one in the United States and the second in Asia.

The world's longest prestressed construction, the three-mile section of a toll bridge across Tampa Bay, has now been completed. This bridge forms the last important link in the Gulf Coast Highway along Florida's west coast. The total length of the crossing is 15 miles and includes a double-leaf bascule bridge with concrete approach trestles, two other steel bridges and two prestressed-concrete trestle crossings. The consultants for the State of Florida were Parsons, Hall Brinckerhoff and Macdonald, of New York, and the general contractors Hardaway Contracting Company, of Georgia; the prestressed design was provided by McCalls Macalloy, Limited, Sheffield, and Mr. Donovan Lee, M.I.C.E., consulting engineer, of London, in conjunction with the Preload Company of New York.

The chief bridge engineer of Florida State Highway Department, Mr. W. E. Dean, has also used the Lee-McCall system for his design of the new Gandy bridge which is being constructed in the same area. This will have 20 spans of 72 ft. and 252 spans of 48 ft., giving a total length of prestressed construction of a little over 2½ miles. The Lee-McCall system of prestressing is also being used for a new warehouse for Boeing Aircraft Corporation at Seattle. The warehouse is 600 ft. long and 450 ft. wide and requires more than 600 prestressed-concrete beams.

Successful tests have now been completed on the bridge which spans the Lower Sind Barrage at Kotri, where the hydraulic works planned by the Pakistan Government, and being carried out by the Public Works Department of Sind, are nearing completion. This bridge is believed to be the longest prestressed-concrete bridge so far built in Asia, comprising 43 spans each of 67 ft. to give a total length of 2,881 ft. The designers and constructors of the superstructure are the British firm of Gammon Pakistan Limited, whose London offices are at 16 Caxton-street, Westminster; the design of the structure has been in accordance with Mr. Freyssinet's principles.

Labour Notes

WORK FOR THE OVER 40's

Methods of overcoming the difficulties of finding work for men and women over 40 years of age are suggested in a committee report presented to the London Liberal Party last Saturday.

The committee considers that it is of national importance that the problem should not be left over, but tackled now, while it is of manageable size. There is no guarantee that the present boom period will last indefinitely and, if not dealt with now, it may be a case of trying to cope with a much greater problem " by hasty improvisation," at a time when depression brings disaster to many of the country's older men and women. Such persons, the committee points out, would be among the first to be discharged.

Unemployment figures are at a low level to-day, but, even so, the committee emphasises, over 60 per cent. of the men and nearly 42 per cent. of the women wholly unemployed in Great Britain in mid-June last year were over 40 years old.

Another point stressed by the committee is that, owing to obstacles, which should be removable, the nation is losing the experience of people who have reached an age when they are most likely to be in a position to give settled and mature service.

OBSTACLES TO BE OVERCOME

Difficulties to be solved are discussed by the committee under four headings. On the question of pensions, the committee regards the structure of many superannuation schemes as presenting an outstanding problem.

It supports the Phillips Committee in advocating that arrangements should be made to enable the accrued pension rights of a person with substantial service to be preserved on a change of employment, including movements between the public services and private employment.

To overcome the " traditional bias," by employees, the committee suggests that the " rate for the job " should be paid regardless of age, so that the employment of older men and women would not cause unemployment by introducing cheap labour. In types of work where promotion is made within the firm, the entry of older workpeople should not interfere with the existing order of priority.

Much of the bias by employers, the committee considers, is only an excuse for concealing the real reasons for objecting to engaging older persons. The committee is in favour of certain changes in the organisation and practice of the Ministry of Labour and National Service, such as the setting up of special departments to deal with experienced men and women, and the omission of any reference to age in questionnaires to employers. The remaining heading refers to the special difficulties encountered by women.

The report is due to be submitted to the consideration of the full Council of the Liberal Party and it is expected that a copy will be presented to the Minister of Labour at a later date.

UNEMPLOYMENT BENEFIT CHANGES

One effect of new regulations regarding the payment of unemployment benefit has been to increase the amount which an unemployed man can earn in a spare-time job, without losing his benefit, from 3*s.* 4*d.* a day to 6*s.* 8*d.* a day. The regulations, which were made on the recommendation of the National Insurance Advisory Committee and are known as *The National Insurance* (*Unemployment and Sickness Benefit*) *Amendment Regulations*, 1955 (H.M.S.O., price 2*d.* net) came into force on February 3.

Amendments made also include a definition of " unemployment," in relation to people claiming unemployment benefit who place restrictions of various kinds on the sort of work they are willing to take. This clarification of the rules, the Advisory Committee states, is intended to eliminate inconsistencies in the application of them to specific cases.

Alterations under this heading will mainly affect persons who, as a result of the restrictions they put on the work they are willing to take, have no reasonable prospects of getting a job. Generally speaking, these people will not receive unemployment benefit in future, unless their lack of prospects in getting the kind of jobs they want is due simply to adverse industrial conditions of a temporary nature.

The position of disabled persons is adequately safeguarded, as, under the new regulations, no account is taken of restrictions which are due to physical disabilities.

Even in cases where it cannot be claimed that a man's lack of prospects of work are due to adverse trade conditions or to his disability, he may still be eligible for unemployment benefit if the restrictions he has put on the work he will do are reasonable in view of his usual occupation and the time he has been out of work.

WATERMEN'S WAGE AGREEMENTS

Higher rates of pay, to come into operation as from Monday next, have been accepted by the executive council of the Watermen, Lightermen, Tugmen and Bargemen's Union, according to an announcement issued last Saturday. The new rates provide for a flat increase of 2*s.* 6*d.* a shift (15*s.* a week) on all bonus payments for the union's members.

Originally, bonuses were payable to watermen and lightermen only in cases where they were employed on a ship in which other dock employees were working at piece rates. Lately, however, the bonus has been granted in a variety of other circumstances.

Some time ago, the union presented claims for an advance of 2*s.* 6*d.* a day in the bonus rate and, being dissatisfied with the port employers' offers, gave three weeks' notice on January 21, to terminate its current wage agreements. At the same time, it was announced by the Lighterage Joint Committee that the notice to end the wage agreements was not to be taken as a notice to withdraw the men's labour and that discussions between the two sides were proceeding normally.

As a result of the satisfactory conclusion of these negotiations, the union announcement stated, the notice to end the wage agreements had been cancelled. Between 4,000 and 4,500 members of the union are at work in the Port of London and a considerable proportion of these men will benefit from the increase.

CLERICAL STAFFS' PAY

Strenuous efforts are being made by the clerical and supervisory staffs' section of the Transport and General Workers' Union to secure improvements in the rates of pay for salaried employees in the engineering group of industries, according to a report in the February issue of the *Transport and General Workers' Record*, the union's official journal.

In addition, it is stated, the union is striving hard to obtain an agreement for three weeks' annual holiday for all clerks in these industries who are 21 years of age or over and who have been in the service of their employers for at least twelve months. As soon as it is possible to report progress, branch officers of the union will be informed.

Attention is also being given by the union to needs of the clerical grades of the National Dock Labour Board, the Inland Waterways, and British Road Services, as well as to the divisional staffs of the National Coal Board.

In the electricity-supply industry, an agreement has been reached, through the National Joint Council, for the revision of the present salary structure of the clerical and administrative grades. With effect from January 1 last, two salary scales have been adopted for the general clerical grades, the higher rates being applicable as a reward for improved efficiency and a better standard.

All employees on the general clerical scale were due to be transferred to the higher scale as from January 1 last. A very important feature of the agreement, the union points out, is that the rates for women employees, under both scales, have been brought a little nearer to those applicable to men.

UNDERGROUND RAILWAY EMPLOYEES' WAGES

Some measure of failure attended the further efforts at direct wage negotiation between the London Transport Executive and the National Union of Railwaymen last Friday.

An official announcement issued by the Executive after the discussions had ended stated that a resumed meeting of the London Transport Railway Negotiating Committee, which comprises representatives on both sides, had taken place on that day.

London Transport Executive, it was declared, had offered rates of pay, which, with the exception of the rate for motormen, were at least as high as the rates recently accepted by the union for employees in the comparable grades of British Railways. In many cases, the rates were actually higher than for the comparable grades on the main-line services. Proposals for a minimum wage of £7 a week were included in the Executive's offer. The increases suggested ranged from 7*s.* 6*d.* to 12*s.* 6*d.* a week.

As no agreement was reached at the meeting, the Executive proposed that the matter should be referred to the London Transport Railway Wages Board, which is an independent organisation, for determination. Such procedure, it may be recalled, would be in accordance with the agreement reached between the Executive and the union on January 18.

MOTORMEN'S RATES

There is a common rate on British Railways for steam-engine drivers and motormen. In recent negotiations with the N.U.R. covering British Railways Staff, the considerations which were taken into account in determining the rate for drivers were those which related to a steam-hauled railway and the nature of a steam driver's duties.

The Executive is not satisfied that the rate of £9 18*s.* a week, agreed upon by British Railways and the N.U.R. for drivers of steam engines, is necessarily the proper rate for motormen on London Underground Railways, in view of the different conditions of operation and the very large number of mechanical and electrical aids, including safety devices, which have been introduced over the years.

The representatives of the N.U.R. and the Associated Society of Locomotive Engineers and Firemen present at last Friday's meeting of the Railway Negotiating Committee undertook to report the position to the executive committee of their respective unions. Meanwhile, a strike is promised, unofficially for Monday.

NOTICES OF MEETINGS

Association of Bronze and Brass Founders

WOLVERHAMPTON
"Shell-Moulding Process," by J. L. Rice. Meeting arranged under the Association's advisory service scheme. Victoria Hotel, Wolverhampton. Tues., Feb. 15, 2.15 p.m.

Association of Supervising Electrical Engineers

LONDON
"Cathodic Protection," by Dr. W. F. Higgins. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Feb. 15, 6.30 p.m.
"Regulations of Institution of Electrical Engineers," by J. J. Looker. South-West London Branch. 32 Worple-road, Wimbledon, S.W.18. Wed., Feb. 16, 8.15 p.m.
MANCHESTER
"Relays and Automatic Control in Industry," by Dr. W. L. Stern. Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., Feb. 16, 7.30 p.m.
NOTTINGHAM
"Development and Application of Time Switches," by E. M. Selley. Nottingham Branch. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Wed., Feb. 16, 7.30 p.m.
OXFORD
"Fluorescent Lighting: Maintenance, Colour Changing and Dimming," by H. Hewitt. Oxford Branch. Y.M.C.A., 10 George-street, Oxford. Sat., Feb. 19, 6.30 p.m.

Chadwick Public Lecture

LONDON
"Clean Air," by Sir Hugh Beaver. Royal Institution, 21 Albemarle-street, W.1. Mon., Feb. 14, 5.30 p.m.

Chemical Engineering Group

LONDON
"Applications of Chemical Engineering in the Fine Chemicals Industry," by W. C. Peck; and "Vacuum Freeze-Drying," by A. S. D. Barrett. King's College, Strand, W.C.2. Fri., Feb. 18, 7 p.m.

Chemical Society

LONDON
Various original papers. Thurs., Feb. 17, 7.30 p.m.
CAMBRIDGE
"Physical Chemistry of Acetaldehyde Solutions," by R. P. Bell. Cambridge Branch. University Chemical Laboratory, Pembroke-street, Cambridge. Fri., Feb. 18, 8.30 p.m.
GLASGOW
Annual General Meeting. Glasgow Branch. Royal Technical College, Glasgow. Fri., Feb. 18, 7 p.m.
GLOUCESTER
"New By-Products from Coal," by Dr. W. Idris Jones. Bristol Branch. College of Technology. Thurs., Feb. 17, 7 p.m.
SOUTHAMPTON
"Recent Work on Inclusion Compounds," by Professor W. Baker. Southampton Branch. Chemistry Department, The University, Southampton. Fri., Feb. 18, 5 p.m.

Diesel Engine Users Association

LONDON
"Prevention of Scale and Corrosion in the Water-Cooling Systems of Internal-Combustion Engines," by E. L. Streatfield. Caxton Hall, Westminster, S.W.1. Thurs., Feb. 17, 2.30 p.m.

Illuminating Engineering Society

LIVERPOOL
"Design and Application of Flameproof Lighting Equipment," by D. A. Strachan. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Tues., Feb. 15, 6.30 p.m.
MIDDLESBROUGH
"Design and Application of Flameproof Lighting Equipment," by D. A. Strachan. Tees-Side Group. Cleveland Scientific and Technical Institute, Corporation-road, Middlesbrough. Wed., Feb. 16, 6.30 p.m.
SHEFFIELD
"Some Aspects of Industrial Lighting from a Factory Inspector's Viewpoint," by D. E. Jones. Sheffield Centre. The University, Western Bank, Sheffield, 10. Mon., Feb. 14, 6.30 p.m.
PRESTON
"Lighting for Sport," by A. Wilcock. North Lancashire Group. Offices of the North-Western Electricity Board, 19 Friargate, Preston. Wed., Feb. 16, 7.15 p.m.

Incorporated Plant Engineers

BLACKBURN
"Statutory Requirements in Connection with Boilers and Other Pressure Vessels," by G. A. Anderson. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Feb.17, 7.30 p.m.
BRISTOL
"Protection of Structural Steel Against Corrosion," by K. H. Gibbons. Western Branch. Grand Hotel, Bristol. Wed., Feb. 16, 7.15 p.m.
DUNDEE
"Thermal Insulation," by D. I. Smith. Dundee Branch. Mathers Hotel, Dundee. Mon., Feb. 14, 7.30 p.m.
GLASGOW
"Works Capital Expenditure," by F. Franklin. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow. Wed., Feb. 16, 7 p.m.
LIVERPOOL
"Electronic Control," by G. Horsfall. Merseyside and North Wales Branch. Royal Institution, Colquitt-street, Liverpool. Thurs., Feb. 17, 7.15 p.m.
ROCHESTER
"Industrial Gas Turbines," by J. R. Needham. Kent Branch. Bull Hotel, Rochester. Wed., Feb. 16, 7 p.m.
SWANSEA
"Refrigeration as Affecting Industry," by D. E. Hall. South Wales Branch. Mackworth Hotel, Swansea. Tues., Feb. 15, 7.15 p.m.

Institute of British Foundrymen

COVENTRY
"Shell Moulding of Cylinder Castings," by A. Emmerson. Coventry Section. Coventry Technical College, Coventry. Tues., Feb. 15, 7.30 p.m.
DERBY
"Factors Governing Graphite Formation in Cast Iron," by P. A. Russell. East Midlands Branch. College of Arts, Derby. Sat., Feb. 19, 6 p.m.
IPSWICH
Brains Trust Meeting. East Anglian Section. Public Library, Ipswich. Tues., Feb. 15, 7.30 p.m.
SLOUGH
"Fuel Economy and Furnace Design," by F. Hudson; and "Cupola Developments," by A. R. Parkes. Slough Section. Offices of High Duty Alloys Ltd., Slough. Tues., Feb. 15, 7.30 p.m.

Institute of Fuel

BIRMINGHAM
"Fuel Economy and Breweries," by J. Hall. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Tues., Feb. 15, 6 p.m.
LEEDS
"An Approach to Fuel Economy in a Large Engineering Works," by F. A. Worsley. Yorkshire Section. Hotel Metropole, Leeds. Wed., Feb. 16, 2.30 p.m.
NEWCASTLE-ON-TYNE
Students' Evening. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Feb. 14, 6.30 p.m.

Institute of Marine Engineers

LONDON
"Boilers," by Lieut. Commander A. P. Monk. Student Lecture. Mon., Feb. 14, 6.30 p.m.
BIRKENHEAD
"Marine Closed-Feed Systems," by D. C. Hagen. Junior Lecture. Merseyside and North-Western Section. Technical College, Birkenhead. Wed., Feb. 16, 7 p.m.

Institute of Metals

BIRMINGHAM
"Treatment of Swarfs, Sawings and Residues in the Non-Ferrous Metals Industries." All-Day Discussion. The University, Edgbaston, Birmingham. Wed., Feb. 16, 10.30 a.m. to 4.30 p.m.
GLASGOW
"New Developments in Nickel Alloys," by A. B. Graham and C. C. Horne. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Feb. 14, 6.30 p.m.

Institute of Road Transport Engineers

LONDON
"Trends in Vehicle Compression-Ignition and Petrol Engine Lubrication," by F. Lawrence. Royal Society of Arts, John Adam-street, W.C.2. Thurs., Feb. 17, 6.30 p.m.
LEEDS
"Metal Spraying and Reclamation," by L. Manuel. Yorkshire Centre. Hotel Metropole, King-street, Leeds. Thurs., Feb. 17, 7.30 p.m.
LIVERPOOL
Discussion on "Production of Diesel Engines." North-West Centre. Adelphi Hotel, Liverpool. Wed., Feb. 16, 7.30 p.m.

Institute of Welding

GLASGOW
"Modern Practice in the Welding of Pipes," by E. Fuchs. West of Scotland Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Feb. 16, 7 p.m.
LEEDS
"Structural Steel Design," by R. J. Fowler. Leeds Branch. Great Northern Hotel, Leeds. Thurs., Feb. 17, 7.30 p.m.

Institution of Chemical Engineers

MANCHESTER
"Particle-Size Distribution Analysis by Centrifugal Sedimentation," by J. K. Donoghue and W. Bostock. North-Western Branch. College of Technology, Manchester. Fri., Feb. 18, 7 p.m.

Institution of Civil Engineers

LONDON
"Investigations into the Designs of Pressure Tunnels in London Clay," by F. Tattersall, T. R. M. Wakeling and W. H. Ward. Tues., Feb. 15, 5.30 p.m.
MANCHESTER
"Process Buildings at Capenhurst: Some Structural Problems," by T. C. Waters. North-Western Association. College of Technology, Manchester. Mon., Feb. 14, 6.30 p.m.
LOUGHBOROUGH
"Flood on the Lincolnshire Coast and Remedial Measures," by J. Finn. Loughborough College. Wed., Feb. 16, 7 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Teaching Faraday's Law of Electromagnetic Induction," opened by P. Hammond. Education Discussion Circle. Mon., Feb. 14, 6 p.m.
"The Service Engineer at an Atomic Energy Establishment," by W. E. Harris. Measurements Section. Tues, Feb. 15, 5.30 p.m.
"Introduction to Study of Servo-Mechanisms," by P. J. Bhatt; "The Development of 50-Cycles Traction in France," by E. J. Davies; and "Electricity Applied to Oil Production," by G. Gascoigne. Utilization Section. Thurs., Feb. 17, 5.30 p.m.
NEWCASTLE-UPON-TYNE
"Possibilities of a Cross-Channel Power Link Between the British and French Supply Systems," by D. P. Sayers, M. E. Laborde and F. J. Lane. North-Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Feb. 14, 6.15 p.m.
PORTSMOUTH
"Owen Falls Hydro-Electric Scheme," by T. A. L. Paton and R. G. T. Lane. Southern Centre. College of Technology, Portsmouth. Thurs., Feb. 17, 6.30 p.m.

Institution of Heating and Ventilating Engineers

MANCHESTER
"Electrical Storage Heating: A Recent Installation," by G. Fisher. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Feb. 18, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Report on "Investigation into the Failure of the Two 100-MW Turbo-Generators," by Sir Claude Gibb. Tues., Feb. 15, 5.30 p.m.
"Pulsating Flow Measurement by Viscous Meters, with Particular Reference to the Air Supply of Internal-Combustion Engines," by Professor L. J. Kastner and Dr. T. J. Williams. Fri., Feb. 18, 5.30 p.m.

Institution of Mining and Metallurgy

LONDON
"Preparation of Hydraulic Backfill at Kerr-Addison Gold Mines Ltd., Virginiatown, Ontario," by G. J. Hawkes; "Attempts at Sealing Off River Water from Underground Workings in North Wales," by J. B. Richardson, condensed from a report by J. L. Francis and J. Thomson-Jacob; and "Economic Aspects of the Definition of Ore," by D. Carlisle. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Feb. 17, 5 p.m.

Institution of Production Engineers

BIRMINGHAM
"The Skilled Man in Industry," by J. T. Bolas. Birmingham Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Feb. 16, 7 p.m.
GLASGOW
"Productivity and the Machine Tool," by N. Stubbs. Glasgow Section. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 17, 7.30 p.m.
LIVERPOOL
"Packaging," by A. Frazer Much. Liverpool Section. Exchange Hotel, Liverpool. Wed., Feb. 16, 7 p.m.
SHEFFIELD
"Manufacture of Engineers' Cutting Tools," C. A. Grayson. Sheffield Section. Grand Hotel, Sheffield. Mon., Feb. 14, 6.30 p.m.
SOUTHAMPTON
"Resistance Welding: Its Early History and Modern Development," by Dr. H. G. Taylor. Southern Section. Polygon Hotel, Southampton. Wed., Feb. 16, 7.15 p.m.

Institution of the Rubber Industry

BIRMINGHAM
"Racing Tyre Design," by D. C. Hartley. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Feb. 14, 6.45 p.m.
CARDIFF
"Recent Developments in Processing", by T. H. Messenger. South Wales and Monmouthshire Section. Cardiff College of Technology, Cardiff. Mon., Feb. 14, 7.30 p.m.

Institution of Water Engineers

LONDON
Film Evening. South-Eastern Section. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 16, 2.30 p.m.

Junior Institution of Engineers

LONDON
"The Atom," by S. A. McAuliffe. Fri., Feb. 18, 7 p.m.
SHEFFIELD
"Blast-Furnace Plant and Operational Problems," by E. A. Cotterill; and "Electrical Equipment and Services for the Blast-Furnace Plant at Park Gate Iron and Steel Works," by H. Demaine. Sheffield Section. Mon., Feb. 14, 7.30 p.m.

Manchester Association of Engineers

MANCHESTER
"Some Aspects of Drop-Forging Practice," by K. Fidler. Engineers' Club, Albert-square, Manchester. Fri., Feb. 18, 6.45 p.m.

Royal Aeronautical Society

LONDON
"Problems Associated with Stress Concentration," by H. L. Cox. Thurs., Feb. 17, 7 p.m.

Royal Meteorological Society

LONDON
"Meteorology in a Large Water-Engineering Project," by Dr. E. B. Kraus. Wed., Feb. 16, 5 p.m.

The Royal Society

LONDON
"Irregular Structure of the Outer Regions of the Solar Corona," by A. Hewish; and "Preliminary Experiments on the Temperature-Wave Method of Measuring Specific Heats of Metals at Low Temperatures," by D. H. Howling, E. Mendoza and J. E. Zimmerman. Thurs., Feb. 17, 4.30 p.m.

Royal Society of Arts

LONDON
"Welfare in a Large Family Firm," by the Hon. H. A. Cozens-Hardy. Wed., Feb. 16, 2.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Bronze and Brass Founders, 69 Harborne-road, Edgbaston, Birmingham 15. (Edgbaston 4141.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Chadwick Trust, 204 Abbey House, Westminster, London, S.W.1. (ABBey 6872.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engine Users Association, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (MONarch 2096.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1. (ABBey 6740.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 20 Booth-street, Manchester 2. (Central 2796.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)